Borderline Personality Traits and Emotion Processing: An Event-Related Potentials Study

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December, 2005

Submitted in partial requirement for the degree of Master of Psychology (Clinical) at the University of Tasmania

I declare that this thesis is my own work and that, to the best of my knowledge and belief, does not contain material from unpublished sources without proper acknowledgement, nor does it contain material which has been accepted for the award of any other higher degree or graduate diploma in any university.

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Literature Review

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Abstract

Linehan's (1993) biosocial model of Borderline Personality Disorder (BPD) proposes that the core behaviours of BPD (e.g., interpersonal difficulties, self-harm, and impulsivity) are due to the BPD patient being unable to regulate their emotions to suit their environment. BPD patients are assumed to be more sensitive and accurate at responding to emotional cues than other people. Partial support for the theory has been provided (e.g., Wagner & Linehan, 1999) but there is a contradiction in the literature as some researchers have found that BPD patients are more accurate at identifying emotional cues than others (e.g., Frank & Hoffman, 1986) and others have found that they are less accurate (e.g., Arntz & Veen, 2001). This review examines the neuropsychological psychophysiological and biological evidence for the biosocial model and discusses the limitations of the existing research.

Borderline Personality Disorder (BPD) is defined as a persistent pattern of volatility in interpersonal relationships, fluctuating self-image and emotions and noticeable impulsivity that is observable in a range of social contexts and apparent by early adulthood (American Psychiatric Association; APA, 2000). BPD is characterised by an unstable self-image, persistent feelings of emptiness, desperate efforts to avoid real or imagined abandonment, inappropriate anger or difficulties controlling anger, suicidal behaviour or threats and self-harm behaviour (Skodol et al., 2002). In addition, it is identified by paranoia or dissociative symptoms, affective instability, impulsivity in at least two areas that are destructive (e.g., binge eating, substance abuse), and unstable and passionate interpersonal relationships marked by alternating between extremes of idealisation and devaluation (Terbartz van Elst et al., 2001).

Although BPD is relatively common, affecting about two percent of the general population (Clarkin, Levy, Lenzenweger, & Kernberg, 2004), little is known about the aetiology of this disorder and it is notoriously difficult to treat (Sansone & Levitt, 2005). Linehan's (1993) biosocial theory of BPD proposes that the key diagnostic features of BPD (e.g., interpersonal problems, impulsivity, and self-harm) are the result of the BPD patient being overly sensitive to emotional information in their environment and thus respond to unemotional information as though it is emotional in nature, or respond with an extreme emotional reaction to only mildly emotional cues. Very little is known about the exact nature and components of emotional processing in BPD patients.

This review examines the neuropsychological, psychophysiological and biological evidence for Linehan's (1993) biosocial theory of BPD. Beginning with a summary of the clinical features, prevalence rates and demographical information pertinent to BPD, the review then examines the literature regarding genetic influences on the development of BPD and emotional processing in general. This is followed by a summary of theories of BPD, empirical studies of emotional processing in general, and empirical evidence for a difficulty in emotional processing in BPD patients. The review concludes by summarising the key results and limitations of research in this area and offering some suggestions for future research.

Overview of Borderline Personality Disorder

Description and Clinical Features

BPD is possibly one of the most common personality disorder diagnoses employed in mental health settings today (Ha et al., 2004), as up to 10% of outpatients and 20% of inpatients are diagnosed with the disorder in mental health clinics in the United States alone (APA, 2000; Johnson, Hurley, Benkelfat, Herpertz, & Taber, 2003). BPD is a severe, persistent pattern of behaviour that is characterised by instability in interpersonal relationships, an unstable sense of self, fluctuating affect, intense emotional experiences and severe difficulties in relating to others (Trull, Stepp, & Durrett, 2003). It is marked by impulsivity, suicidal behaviour, paranoia or dissociative feelings, inappropriate anger, and fears of abandonment (Hooley & Hoffman, 1999; Millon, 2000). Patients afflicted with BPD form intense and unstable relationships, they frantically attempt to avoid real or imagined abandonment, fail to maintain a stable sense of identity, and experience profound feelings of emptiness (Coolidge, Segal, Stewart, & Ellett, 2000). BPD can affect an individual's ability to operate on a behavioural (e.g., impulse control), emotional (e.g., extreme mood reactivity), interpersonal (e.g., volatile relationships), and cognitive (e.g., dissociation) level (Cheavens et al., 2005).

Prevalence Rates and Demographical Information and Co-morbidity

Although BPD is a relatively rare condition in the general population, affecting about two percent of people in the United States (Bland, Williams, Scharer, & Manning, 2004), it has been reported to affect up to 10% of patients seen in outpatient mental health settings and 20% of those seen in inpatient settings (APA, 2000; Johnson et al., 2003). It has been suggested that BPD may be the most prevalent of the personality disorders with one study showing that approximately eight percent of all outpatients and 27% of inpatients with a diagnosis of a personality disorder meet the criteria for a diagnosis of BPD (Pinto, Dhavale, Nair, Patil, & Delwan, 2000). In addition, researchers have estimated that up to 50% of all psychiatric inpatients diagnosed with a personality disorder are also eligible for a diagnosis of BPD (Ha et al., 2004).

In general, BPD is diagnosed more frequently in young adults (Stone, 1990) and it is especially prevalent in females, with the *Diagnostic and Statistical Manual-4th edition* (DSM-IV; APA, 2000) indicating that it is diagnosed as often as 75% in females. Although it is not quite clear why this disorder is so sex selective, a 3:1

gender ratio is quite unusual for a mental disorder, there do appear to be distinct sex differences in symptom presentation (Skodol & Bender, 2003). In mental health settings, female BPD patients have been shown to display a greater amount of histrionic behaviour, self-harm behaviour, restricted eating behaviour, and post-traumatic stress disorder symptomatology than male patients with BPD. In contrast, male BPD patients have been found to be more likely to exhibit antisocial behaviour (e.g., fighting) and substance abuse behaviour than female patients (Johnson et al., 2003). Some researchers have thus suggested that the difference in prevalence rates for males and females may be the result of BPD behaviour being perceived and diagnosed as antisocial personality disorder, instead of BPD, in males more often than in females (e.g., Sansone & Levitt, 2005; Skodol & Bender, 2003).

Other researchers, however, have argued that BPD may be more common in females because of the greater incidence rates of childhood sexual abuse in female patients and the widely reported link between childhood sexual abuse and the later development of BPD (e.g., Guttman & Laporte, 2000). Hormonal differences between the sexes may also have some impact. De Soto, Geary, Hoard, Sheldon, and Cooper (2003) studied the effects of female menstruation on the presentation of BPD and found that fluctuations in oestrogen levels can affect the expression of BPD.

As with any diagnosis, cultural differences may also have an impact on prevalence rates. BPD is most commonly reported in western countries, such as North America, Europe, Australia, and the United Kingdom (Paris, 1996; Sansone & Levitt, 2005). There has been limited research into cultural differences in BPD and there is very little information regarding prevalence rates in non-western countries or possible differences in symptom presentation. In the United States BPD is one of the most commonly diagnosed personality disorders with the prevalence rate being reported as two percent (APA, 2000), however in Norway the incidence rate of BPD has been found to be less common than other personality disorders (Torgersen, 2000). Using an American sample, Chavira et al. (2003) found the incidence of BPD to be higher in Hispanics than white or black Americans, suggesting that there is a genetic influence.

Reported cultural and sex differences in BPD may be clouded by diagnostic errors. BPD can be very difficult to diagnose in clinical settings as not only do individuals with BPD usually maintain a seemingly intact social façade but in many cases the criteria for another Axis I or Axis II condition is also fulfilled (Sansone & Levitt, 2005; Zimmerman & Mattia, 1999) and as a result these co-morbid disorders may distract the clinician from investigating or identifying BPD features. BPD frequently occurs with Axis I conditions such as mood disorders, substance use disorders, eating disorders, and anxiety disorders (APA, 2000; Ha et al., 2004). Researchers have found (e.g., Skodol et al., 2002) that clinical outcome is worse for BPD patients diagnosed with a co-occurring Axis I condition, than for those solely diagnosed with BPD.

The life-time prevalence rate for BPD has been shown by some researchers to be relatively low. In a study conducted by Paris and Zweig-Frank (2001) of sixty-four patients who met the diagnostic criteria for BPD, 25% met the diagnostic criteria at a 15 year follow-up, but only 7.8% were still considered eligible for a diagnosis at a 27 year follow-up. The low life time prevalence rate, however, may be partly explained by the finding that about 70% of these patients engage in self-injurious behaviours (Paris, 2002) and thus may not live to an older age. In addition, there is a reported suicide rate of 10%, which is almost 50 times higher than that of the general population (Johnson et al., 2003) and most completed suicides have been reported to occur within the first five years of treatment (Paris, 1993).

Common self-destructive behaviours employed by BPD patients include, sexual promiscuity, self-mutilation, and substance abuse and these impulsive behaviours often culminate in frequent hospitalisations (Skodol et al., 2002). These behaviours are of particular concern to clinicians, as not only are they costly in terms of treatment time, but they have been reported to occur in as many as 80% of inpatients diagnosed with BPD (Siever, Torgersen, Gunderson, Livesley, & Kendler, 2002). Many of these self-destructive behaviours linked to BPD are seen as being caused by an inability to inhibit impulsive actions and to process emotions effectively (Levine, 1992; Westen, 1991).

Biological Influences and Family Studies

Positron Emission Tomography (PET) and Magnetic Resonance Imaging (MRI) Studies

Positron Emission Tomography (PET) studies have been employed to examine the biological influences on BPD. Oquendo et al. (2005) studied regional glucose uptake in response to fenfluramine in depressed participants with BPD and depressed participants without BPD finding that BPD with depression is associated with unusual activity in parietotemporal and anterior cingulate cortical regions of the brain. Driessen et al. (2000) found a reduction in the volumes of the hippocampus and the amygdala in female patients with BPD compared to those without a BPD diagnosis.

Using Magnetic Resonance Imaging (MRI) techniques, brain structures known to be involved in the processing of emotions and impulsivity in patients with BPD have been examined (e.g., Kahl et al., 2005). The prefrontal cortex and the amygdala have been shown to be important structures in emotional information processing and impulsivity and it has been shown that both of these areas are disturbed in patients with BPD compared to participants not meeting the BPD diagnostic criteria (Terbartz van Elst et al., 2001). Trull et al. (2003) found a 19% decrease in the total density of neurones in the dorsolateral prefrontal cortex in BPD patients compared to participants not diagnosed with BPD, which they hypothesised suggests a reduced amount of neurones or a disturbance in the micro-structure of the neurones in this structure.

Hippocampal and amygdala volumes in BPD in comparison to participants not diagnosed with the disorder have been measured in other MRI studies. Schmahl, Vermetten, Elzinga, and Bremner (2003) measured hippocampal and amygdala volumes in 10 patients with BPD and 23 participants not diagnosed with BPD. Patients with BPD were found to have a 21.9% smaller mean amygdala volume and a 13.1% smaller hippocampal volume. Terbartz van Elst et al. (2003) found a 24% reduction of the left orbitofrontal and a 26% reduction of the right anterior cingulate cortex in patients diagnosed with BPD compared to participants not meeting the diagnostic criteria for BPD. The results of this research suggest that some of the difficulties experienced by BPD patients in processing emotional information may be associated with alterations in the amygdala and other limbic structures (Ebner-Priemer et al., 2005).

Many researchers believe that the core behaviours of BPD (e.g., interpersonal problems, suicidal gestures, and impulsive actions) are a direct function of the BPD patient's inability to regulate their emotions to the emotional cues in their environment correctly (e.g., Linehan, 1993; Sanislow et al., 2002; Siever et al., 2002). Although the neurobiological basis of affect dysregulation is still unclear, a recent study suggests that higher activity of the amygdala may play an important role. Using functional MRI technology, Herpertz et al. (2001) had six female BPD patients and six age and sex matched participants not diagnosed with BPD view 12 emotionally unpleasant slides and 12 emotionally neutral slides. Significantly higher activity of the amygdala was observed in BPD patients to unpleasant slides and this enhanced amygdala activation in BPD patients was proposed to reflect their intense reaction to emotionally rich material.

Twin and Family Studies

Following from the above studies suggesting that BPD patients have biological differences in the brain regions associated with the processing of emotions compared to people without BPD, researchers have examined genetic influences on BPD (e.g., Pally, 2002). In a Norwegian study of seven monozygotic and 18 dizygotic twin pairs, concordance rates for BPD were found to be zero for monozygotic twins and 11% for dizygotic twins (Torgersen, 1987). This study suggests that genetics may play a less significant role in the development of BPD than environment however a very small sample was investigated. In a larger Norwegian study, the genetic influence on BPD was found to be more significant (Torgersen, 2000). In this study of 221 twin pairs, 97 monozygotic and 129 dizygotic pairs were examined and the concordance rate for definite BPD was found to be 35% for monozygotic twins and seven percent for dizygotic twins. In addition, concordance rates were examined for subthreshold BPD, where only one or two criteria for BPD were met, and the concordance rates were found to be 38% for monozygotic twins and 11% for dizygotic twins.

Other research has supported a genetic contribution to BPD. BPD has been found to have a higher occurrence in biological than adoptive relatives (Pally, 2002) and the morbid risk for BPD is higher in first degree relatives of BPD patients (11.5%) than in the general population (Skodol et al., 2002). In summary, although there is some evidence for a genetic predisposition for BPD, further research, using larger samples and more diverse cultural representation is needed before any firm conclusions can be drawn.

Theories of Borderline Personality Disorder

Kernberg's (1984) Theory

The biological influences on BPD are explained by researchers in different ways depending on the particular theoretical model that they are following (Hooley &

Hoffman, 1999). Kernberg (1984) proposed that the core feature of BPD was an inherited aggressive drive that was associated with the individual's biological inability to tolerate high levels of anxiety. The aggressive behaviours associated with BPD, such as outbursts of rage, extreme irritability, and unstable interpersonal relationships, are thus viewed by Kernberg, as being a result of the individual's inherited excess of aggression. While there is some evidence of aggressive traits being inherited (e.g., Pally, 2002) there is still limited evidence, as mentioned above, of BPD traits being inherited.

Attachment Theories

In contrast, attachment theories of BPD place more importance on the environment in which the individual develops rather than underlying genetic influences (Meyer, Pilkonis, & Boevers, 2004). Childhood abuse is a common feature in the histories of BPD patients (Yen, Zlotnick, & Costello, 2002) and it is proposed that this early maltreatment leads to difficulty in being able to value and understand other people's emotional states (Fonagy, 2000) and a tendency to interpret other people's actions as being malevolent (Arntz & Veen, 2001). Consistent with this theory, researchers have found that BPD patients often view their attachments with others as being insecure and find it difficult to express their feelings towards others (Holmes, 2003).

Linehan's (1993) Biosocial Theory

In recent years, Linehan's (1993) biosocial theory of borderline pathology has been the most widely accepted model because of its usefulness in clinical practice (Hooley & Hoffman, 1999). Linehan proposes that the destructive behaviours of BPD are a function of the individual's inability to regulate their emotions to suit their environment, a phenomenon she labels 'emotional dysregulation'.

BPD patients are perceived as possessing both an excess and a deficit in emotional processing. They have been observed to respond to some situations with extreme emotional reactions and to other situations with a decreased or dulled emotional response (Figueroa & Silk, 1997). The behaviours characteristic of BPD are viewed as being related to this deficiency or surplus in emotional processing and the BPD patient's inability to regulate their emotions to fit their environment (Hooley & Hoffman, 1999). For example, some behaviours may be unconscious low emotional reactions to extremely distressing emotions (e.g., dissociative behaviour) and other behaviours may be more emotional and serve to reduce intense unpleasant emotional experiences (e.g., self-harming behaviour, inappropriate anger) (Yen et al., 2002).

Linehan (1993) perceives patients with BPD as possessing an underlying vulnerability to emotional information. She believes they are overly sensitive to emotional cues in their environment (especially negative emotional cues) and they possess a low tolerance for emotional reactivity and that this leads to a fast reaction to emotional cues. This implies that BPD patients are sensitive perceivers of emotional information and that they are reacting to real emotional information in their environment rather than responding to misinterpreted cues that do not really exist (Korfine & Hooley, 2000).

Linehan (1993) believes that the cause of this emotional vulnerability is partly biologically based but exacerbated by the child being raised in an environment in which he or she is taught that his or her emotional reactions or needs are somehow wrong or invalid, a phenomenon she labels the 'invalidating environment'. This environment may take the form of physical abuse, hostility, separation, neglect, sexual abuse, or emotional abuse. Researchers (Wagner & Linehan, 1999) have identified the environment in which childhood sexual abuse occurs as being the prototypic example of the invalidating environment. An invalidating environment may also involve constant criticism, punishment, trivialising of emotional matters, erratic reinforcement, and poor communication of emotions (Cheavens et al., 2005).

Interpersonal Context and BPD

Many of the diagnostic symptoms of BPD (e.g., feelings of emptiness, bursts of rage, impulsivity, fears of abandonment, unstable and intense interpersonal relationships, and affective lability) occur predominantly in an interpersonal context and are frequently caused by real or imagined events in the BPD patient's relationship with another person (e.g., self harm may occur as a result of a fight with another person) (Levy, Meehan, Weber, Reynoso, & Clarkin, 2005).

Patients with BPD often experience intense and unstable interpersonal relationships which are marked with hostility, paranoia and suspicion (Minzenberg, Fisher-Irving, Poole, & Vinogradov, 2006). BPD patients are described by researchers (e.g., Paris, 2005) as alternating between states of intense adulation and devaluation about their feelings for other people and this feature is commonly labelled 'splitting' by psychoanalytic therapists (Allen & Whitson, 2004).

As BPD symptomatology is considered to predominantly occur in an interpersonal context, some researchers have proposed that to understand BPD it is necessary to study the ways in which a BPD patient understands, recognises and processes emotional material that has an interpersonal context (e.g., involves interpreting the emotional state of another person) (Semerari, et al., 2005)

Emotional Processing: Empirical Research

Cognitive Processing

BPD patients have been observed to display a number of cognitive deficits. including, distorted thinking about what occurs in their interpersonal relationships, an inability to recall events accurately and confused and/or contradictory descriptions of events and people (Allen and Whitsun, 2004).

In order to examine whether BPD patients do experience cognitive deficits a few studies have examined these individuals' performance on tasks that involve cognitive processing. O'Leary, Brouwers, Gardner, and Cowdry (1991) found that BPD patients performed at a significantly lower level than participants not meeting the diagnostic criteria for BPD on memory tests requiring uncued recall of previously learned material and that they also experienced difficulties on visual tasks involving separating extraneous from essential visual information. In addition, Lenzenweger, Clarkin, Fertuck, and Kernberg (2004) found that participants with BPD had executive functioning difficulties on the Wisconsin Card Sorting Task compared to participants without BPD. These results suggest cognitive processing difficulties may underlie the ability of patients with BPD to process emotional information as not being able to process visual information or remember information adequately may lead to errors in emotional responding.

The emotional Stroop task is a variant of the standard colour Stroop task. It involves the presentation of emotional and neutral words to participants in a range of different colours. Arntz, Appels, and Sieswerda (2000) used the emotional Stroop task to present four classes of negative words (negative views of others, sexual abuse related words, negative self-descriptors, and general negative words unrelated specifically to BPD) to a group of BPD patients and a group of patients diagnosed with a Cluster C personality disorder (Avoidant, Obsessive-Compulsive, Dependent) and found no group differences between their reactions to all four word types. In a similar study, Korfine and Hooley (2000) presented generally negative words, negative words that were borderline specific (e.g., contained themes of abandonment, anger, self-harm and others being uncaring), generally positive words, and generally neutral words to a BPD group and a group of participants not meeting the diagnostic criteria for BPD. Interestingly, no differences were found between the groups' responses to the words when they were instructed to remember them, however, when instructed to forget the words, the BPD group recalled significantly more of the borderline words than did the other participants. Korfine and Hooley suggested that the BPD patients were unable to stop themselves from processing the borderline words and forget them, even when instructed to do so, because of their heightened sensitivity to emotionally negative material, or 'emotional disinhibition'. This explanation for these results supports Linehan's biosocial theory, as the theory proposes that BPD patients are overly sensitive to emotional information, particularly that which is negative in nature.

Physiological Responses to Emotional Information

Physiological responses and emotional processing of affective stimuli have been investigated by a number of researchers with the use of the International Affective Picture Series (IAPS; Lang, Bradley, & Cuthbert, 1999). The IAPS is a set of slides containing pictures with an emotionally unpleasant content, an emotionally pleasant content or an emotionally neutral content. Slides are also categorised in terms of arousal, with some being high and others being low in arousal. Bradley, Cuthbert, and Lang (1996) showed that in general, individuals take longer to respond to both pleasant and unpleasant pictures than to neutral pictures, which they suggested may be due to emotionally rich pictures involving more attentional resources to process and thus needing more time than neutral pictures. In a series of studies, Herpertz and colleagues (Herpertz, Kunert, Schwenger, & Sass, 1999; Herpertz et al., 2000) have examined the physiological (heart rate, skin conductance, and startle response) and self-report responses to the IAPS slides of BPD patients and participants not diagnosed with BPD in order to add support to Linehan's (1993) biosocial theory of BPD that proposes a heightened response to emotional cues in BPD patients. In one study, Herpertz et al. (1999) studied the responses to the IAPS slides of BPD patients and participants not diagnosed with BPD and found that the BPD patients did not respond with a more intense emotional response to emotional cues, in contrast they had lower electrodermal responses to all the IAPS slides than the participants without BPD. In a later study Herpertz et al. (2000) found similar that BPD and avoidant personality disorder patients responded with similar responses to all three types of slides, and the unpleasant slides, contrary to hypotheses, were responded to very similarly by both groups.

In summary, the studies by Herpertz and colleagues (Herpertz et al., 1999; Herpertz et al., 2000) end support to the biosocial theory of BPD proposed by Linehan, as although the BPD patients in these studies did not respond with heightened physiological arousal to emotional material, as would be expected if they were more sensitive to emotional material, they did respond with less emotion which is also predicted by the model.

Electroencephalograph (EEG) Studies and Borderline Personality Disorder

Research employing standard EEG techniques has been conducted extensively with patients with BPD with the aim of exploring the hypothesised link between abnormal brain electrical activity and impulsiveness and affective instability (Boutros, Torello, & McGlashan, 2003). Most EEG studies have focused on the frequency of eye movements per minute of rapid eye movement (REM) time (REM density) and the period from stage 2 sleep onset to the first REM period (REM latency) (Lahmeyer, Reynolds, Kupfer, & King, 1989). Sleep in general, and REM sleep in particular, have been consistently shown to be abnormal in BPD patients as a group (e.g., Bell, Lycaki, Jones, Kelwala, & Sitaram, 1983; Benson, King, Gordan, Silva, & Zarcona, 1990; De la Fuente, Bobes, Vizuete, & Mendlewicz, 2001), with shorter REM latency (Gurvits, Koenigsberg, & Siever, 2000; Reynolds et al., 1985) and higher REM density (Battaglia, Strombi, Bertella, Bajo, & Bellodi, 1999; McNamara et al., 1984) in BPD patients being reported. These abnormalities are viewed to be influenced by factors including co-existing Axis I psychopathology, family psychopathology, and a personal history of depression (Lahmeyer et al., 1989).

Description of Event-Related Potentials (ERPs)

ERPs provide a useful method for studying the brain processes of patients with BPD (Boutros, Nasrallah, Leighty, Torello, Tueting, & Olson, 1997). ERPs are examined by averaging EEG activity to time-locked stimulus events in such a way that only the EEG activity that corresponds with the onset of a controlled stimulus is retained in the final analysis and EEG activity that does not correspond is averaged out (Lincoln, Bloom, Katz, & Boksenbaum, 1998). The averaging process results in distinct components of the ERP that can be identified by their shape (peaks and troughs), voltage (expressed in microvolts), and latency (measured in milliseconds from the onset of the stimulus to when its peak amplitude is reached) (Empson, 1986). Possibly one of the most extensively studied of the ERP components is the P300, which is a large positive peak that occurs between 250 and 450 ms (on average

300 ms) after the onset of an attended stimulus and is usually elicited by the use of an 'oddball' task, which involves the participant responding to an infrequent target stimulus that has been presented within more frequently occurring stimuli (Gurrera, Salisbury, O'Donnell, Nestor, & McCarley, 2005).

The amplitude of P300 is thought to reflect a number of variables involved in cognitive processing and attention. Amplitude can be affected by factors such as the probability of the stimulus occurring and the meaning attached to the stimulus. P300 amplitude has been found to increase as the probability of the target stimulus occurring decreases (Lincoln et al., 1998). P300 latency and amplitude have been consistently shown to be affected by age, with latency decreasing and amplitude increasing from childhood to adulthood and latency increasing and amplitude decreasing from early adulthood to later adulthood (e.g., Lincoln et al., 1998; Smith, Hillman, & Duley, 2005).

The P300 is believed to index processes such as termination of automatic processing (Rosler, 1983), transfer of information to consciousness (Picton, 1992) and updating of working memory mechanisms (Donchin & Coles, 1988). In recent years, two distinct parts of the P300 component have been identified; P3a and P3b (Gurrera et al., 2005). The P3a occurs earlier and is believed to be related to automatic attention, whereas the P3b component occurs later and is linked to gaol directed attention and memory processes (Meares, Melkonian, Gordon, & Williams, 2005). Reduced P300 amplitude has been linked to a variety of conditions, including alcoholism (Porjesz & Begleiter, 1998), antisocial behaviour (Bauer & Hesselbrock, 1999), and schizophrenia (McCarley et al., 1993).

Another identified component of the ERP is the late positive component (LPC) of the waveform (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000). The LPC occurs later in the waveform then the P300 (400-600ms. post stimulus onset) and has been found to be greater in amplitude in the right than the left parietal hemisphere (Cuthbert et al., 2000). LPC has consistently been shown to vary as a function of emotional valence (Carretié, Iglesias, & García, 1997) and can be investigated in studies using emotional picture processing (Cuthbert et al., 2000).

Event-Related Potentials (ERPs) and Emotional Processing Studies

In a study employing the IAPS, Cuthbert et al. (2000) found that LPC was especially pronounced for pictures that were more emotionally arousing than for pictures that were neutral in content and that there was a longer LPC latency for highly emotional pictures. Both pleasant and unpleasant pictures elicited higher amplitude than neutral pictures, with the pleasant pictures eliciting the highest amplitude supporting the results of Cuthbert, Schupp, Bradley, McManis, and Lang (1998) and Schupp, Junghöfer, Weike, and Hamm (2003), who also found that emotionally rich pictures elicited higher amplitudes, than neutral pictures. Age has also been found to affect ERP responses to the IAPS slides, as Smith et al. (2005) found that older adults (aged 60-71 years) exhibited decreased P300 amplitude and reported more pleasure and arousal to all picture types than younger adults (aged 18-23 years).

Facial Expression, Mood and Event Related Potential (ERP) Studies

The IAPS contains slides depicting pictures with a neutral, unpleasant, or pleasant content, but these pictures do not always involve people or people's facial expressions. To further examine emotional processing a number of studies have used stimuli that depict emotional facial expressions. In a number of studies examining participants responses to angry, fearful, happy, and neutral faces it has been consistently shown that people respond with a shorter reaction time to angry faces than to neutral faces and that they are more accurate at correctly identifying angry faces than neutral faces (e.g., Felmingham, Bryant, & Gordon, 2003; Krolak-Salmon, Fischer, Vighetto, & Mauguiére, 2001). Additionally, in some cases participants have been shown to respond with a faster reaction time and with more accuracy to angry faces than to happy faces (Calvo & Esteves, 2005).

ERPs have also been employed to study the effect of child abuse on the interpretation of emotion in facial expressions. Pollack, Klorman, Thatcher, and Cicchetti (2001) studied the ERP responses of maltreated children and children who had not been maltreated to happy, fearful, angry, and neutral faces. The maltreated children were shown to respond with greater amplitude and accuracy to angry faces than to the other target types whereas the children who had not been maltreated were found to respond faster to the happy faces than to the angry faces. In a similar study, Parker and Nelson (2005) studied the ERP responses to facial expressions of children raised in their biological homes and children who had been reared in an institutionalised setting and had experienced maltreatment. They found that the maltreated group responded with greater amplitude to angry faces than to happy faces compared to the group of children who had not been maltreated. These results suggest that the negative emotional experiences associated with childhood maltreatment may affect the development of the resources necessary for emotional processing in these children. In addition, the results from these studies also provide support for Linehan's (1993) biosocial theory of BPD, which proposes that BPD patients are more sensitive to emotional information and process emotional information differently to other people, partly because they were raised in an invalidating environment in which they received some form of maltreatment.

In a study conducted by Kliegel, Horn, and Zimmer (2003), affective state, or mood, was found to have an effect on ERPs and information processing. Participants were divided into three groups and were shown either a negative, positive, or neutral video tape in order to influence their mood. Reduced P300 amplitude was found in the negative mood condition in comparison to the neutral and positive mood conditions and this was interpreted as suggesting weakened information processing abilities when in a negative mood. The finding of mood effects on information processing abilities has implications for further understanding BPD, as these patients are believed to experience negative emotions more intensely than other people (e.g., Linehan, 1993) and this may in turn affect their ability to process cues in their environment effectively.

Event-Related Potentials (ERPs) and Borderline Personality Disorder

Early studies conducted assessing auditory ERPs in patients with BPD primarily focused on examining the possible link between depression and BPD as it was believed that these two conditions were different behavioural expressions of the same underlying condition (Norra et al., 2003). Blackwood, St. Clair, and Kutcher (1986) found that P300 amplitude was decreased and latency was longer in patients with BPD compared to patients with depression without BPD and participants without a mental health condition. Similarly, Kutcher, Blackwood, St Clair, Gaskell, and Muir (1987), and Kutcher, Blackwood, Gaskell, Muir, and St Clair (1989) found that decreased amplitude and abnormally long latency of the P300 differentiates patients with BPD from patients with major depression and healthy participants not diagnosed with a mental illness. Drake, Phillips, and Pakainis (1991) also found prolonged latencies and decreased amplitudes in BPD patients, supporting the notion that BPD patients process information differently to other people.

Visually evoked ERPs have also been employed to enhance our understanding of BPD. Houston, Bauer, and Hesselbrock (2004) studied visually elicited ERPs in BPD patients using a modified version of the Stroop colour word test and found reduced P300 amplitude and poorer response accuracy in the BPD group than a group of participants not diagnosed with BPD. Lincoln et al. (1998) investigated both visual and auditory evoked ERPs in children with borderline symptomatology and found smaller P300 amplitudes in the BPD group for auditory but not for visual evoked potentials.

As previously indicated, two separate components of the P300 have been identified: P3a and P3b. Meares et al. (2005) found that BPD influenced P3a more than P3b, with enhanced P3a amplitude being shown, but only minor changes for

P3b. They suggested that these abnormalities in P3a activity reflected abnormalities in the limbic structures of the brains of patients with BPD.

Empathy, Emotional Facial Expression Research and Borderline Personality Disorder

Early investigations into empathy in BPD have provided support for a heightened sensitivity to emotional information in BPD patients, as predicted by the biosocial model (Linehan, 1993). Frank and Hoffman (1986) compared the responses of participants diagnosed with BPD and participants who did not meet the diagnostic criteria to a series of video-taped vignettes. Participants were asked to identify the emotional content of each vignette as being either positive or negative. The BPD group were found to be more accurate at identifying both positive and negative emotions than the other participants. In a similar study, involving the correspondence between a participant's assessments of another participant with the participant's own self assessment (Ladisich & Feil, 1988), it was found that patients with BPD were more accurate than other psychiatric groups when assessing other people's emotional states.

Other researchers have found contradictory evidence for greater emotional accuracy in BPD. Arntz and Veen (2001) presented film clips with emotional themes that were particularly relevant to BPD (e.g., involving themes of rejection and abandonment), film clips that had an emotional content, and film clips with a neutral emotional content to a group of BPD patients and a group of participants diagnosed with a Cluster C personality disorder. The BPD group were found to provide more negative evaluations of others than the Cluster C personality pathology group, which, while being in agreement with behavioural observations of BPD patients (e.g., Westen, 1991), does not support the biosocial model which predicts greater accuracy in BPD patients to emotional information.

In research examining BPD patients' ability to recognise facial expressions accurately, there have also been mixed conclusions. Levine, Marziali, and Hood (1997) found that BPD patients demonstrated lower levels of emotional awareness, less ability to coordinate mixed valence feelings, greater intensity of negative emotions, and less accuracy at identifying facial expressions of emotion than a group of patients not diagnosed with BPD. Furthermore, Bland et al. (2004) found that BPD patients were less accurate when recognising facial expressions than other participants. Both of these studies provide evidence that is in direct contradiction to the biosocial theory of BPD, which predicts that BPD patients will be more sensitive to emotional material and more accurate at identifying emotional information than other people.

Wagner and Linehan (1999) studied recognition of facial expressions of emotion by females diagnosed with BPD, females with a history of childhood sexual abuse not diagnosed with BPD, and females with no history of childhood sexual abuse or diagnosis of BPD. The females diagnosed with BPD were found to be more accurate at identifying fear facial expressions than the other groups of females but they were also found to be more likely to perceive negative emotions in the neutral faces and to ascribe the emotion of fear more often to non-fear faces. The researchers concluded that BPD patients are just as accurate at identifying basic emotions as other people however they may have a tendency to misinterpret facial expressions more negatively. This interpretation of the results partially supports the biosocial theory, as it suggests that BPD patients may be just as accurate or sensitive to basic emotions as other people and that their heightened emotional sensitivity is specific to unpleasant emotional material (e.g., fear), rather than to emotional material in general. The tendency to misinterpret neutral faces as being negative, while not specifically predicted by the biosocial theory does seem to fit the model. It has been reported that these patients are sensitive to negative evaluations by others and to negative emotional cues in their environment (e.g., Linehan, 1993) and that they have a tendency to misconstrue the actions of others as being malevolent (e.g., Hooley & Hoffman, 1999). It therefore makes sense that they may also misinterpret neutral facial expressions as being unpleasant in some situations.

Summary, Conclusions and Suggestions for Future Research

In recent years, a lot of research has been generated in which the underlying aetiology of BPD has been examined. Linehan's (1993) biosocial theory of BPD proposes that patients with BPD possess an enhanced sensitivity to emotional information, a phenomenon she labels, 'emotional dysregulation'. The problematic behaviours symptomatic of BPD (e.g., interpersonal difficulties, suicidal gestures, and impulsive actions) are thus seen as being due to the individual's tendency to respond to highly emotional events, especially those that are negative in nature, with either an excess or a deficit of emotional reaction (Figueroa & Silk, 1997).

In order to understand the mechanisms underlying this emotional sensitivity further, the structures of the brain that are involved in emotional processing and impulsive behaviour have been examined in a number of studies. Reduced volume of the hippocampus and amygdala (e.g., Driesson et al., 2000; Schmahl et al., 2003) and a reduced amount of neurones in the prefrontal cortex (Trull et al., 2003) in BPD patients compared with participants without BPD have been found in MRI and PET studies. Herpertz et al. (2001) found that BPD patients had higher activity in the amygdala when viewing unpleasant slides than a comparison group of participants without BPD. Taken together these results suggest that BPD patients may possess structural abnormalities in the regions of the brain involved in the processing of emotional information (e.g., hippocampus and amygdala) and impulse control (e.g., prefrontal cortex).

Neuropsychological studies have also provided evidence for brain structural abnormalities in patients with BPD. BPD patients have been shown to exhibit shorter REM latencies (e.g., Gurvits et al., 2000) and higher REM densities (Battaglia et al., 1999) than people without BPD and early studies using auditory evoked ERPs with BPD patients have consistently found low P300 amplitude and prolonged latency in patients with BPD (e.g., Blackwood et al.,1986). The results from the early auditory ERP studies suggest that BPD patients process information differently to other people however as emotional stimuli were not used in these studies, they do not add to a further understanding of the emotional processing skills of BPD patients. Only one study was found that examined the ERPs of BPD patients with visually evoked stimuli (Houston et al., 2004) but this study did not use information that contained an emotional interpersonal context, such as pictures involving interactions between people or facial expressions of emotion, so it is not useful when attempting to explain the emotional processing mechanisms of patients with BPD.

Mixed support has been found for a heightened sensitivity to emotional information in empathy studies with BPD patients. Some investigators (e.g., Frank & Hoffman, 1986; Ladisich & Feil, 1988) have found that BPD patients were more accurate at identifying emotions than other people, however, other researchers (e.g., Arntz & Veen, 2001) have found that BPD patients were less accurate and that they were more likely to provide negative evaluations of others, especially when the information they were viewing was neutral or ambiguous.

Facial processing studies with BPD patients have provided support for Linehan's (1993) biosocial theory. Wagner and Linehan (1999) found that BPD patients were just as accurate at identifying basic facial expressions, but more accurate at identifying fear facial expressions than other people. However, as also found by Arntz and Veen (2001), they reported a tendency for the BPD group to misinterpret neutral facial expressions as negative, which is not predicted by the biosocial theory. A contradiction in the literature is also present, as other researchers have found that BPD patients have difficulty in interpreting facial expressions correctly (e.g., Bland et al., 2004; Levine et al., 1997) and that they are less accurate at identifying facial expressions.

In summary, although there has been a renewed interest in BPD in the past decade and numerous studies have been undertaken to further understand and explore the notion of a heightened sensitivity to emotional information in these individuals, there are still inconsistencies in the literature concerning whether BPD patients are more or less accurate at processing emotional information and whether there are neuropsychological differences underlying these processes (e.g., Arntz & Veen, 2001; Levine et al., 1997). To date, only one study was identified in which emotional stimuli were used when measuring ERPs in BPD patients (e.g., Houston et al., 2004) and this study examined emotional words rather than pictures involving interpersonal interactions or facial expressions. Research into facial expression processing in BPD (e.g., Wagner & Linehan, 1999) shows promise for supporting Linehan's (1993) theory and providing a deeper understanding of the interpersonal problems that BPD patients experience when dealing with other people however, much more research is needed before any firm conclusions can be drawn as other researchers have found contradictory results (e.g., Bland et al., 2004).

It is proposed that further research combining ERPs with facial expressions of emotion and emotional information with other emotional cues other than facial expressions would aid in leading to a better understanding of the underlying processes involved in the emotional sensitivity of BPD patients. Investigations are needed to examine whether BPD patients are more accurate at responding to emotional information when it involves an interpersonal context, or whether they are just more sensitive to emotional information in general than other people. Further investigation of the reported tendency of BPD patients to be more likely to misinterpret neutral or ambiguous emotional information as being negative (e.g., Arntz & Veen, 2001) is also needed. A deeper understanding of this tendency may aid in explaining why BPD patients react so unusually to other people in an interpersonal situation. Research employing participants who experience borderline traits (i.e., endorse BPD traits but do not meet the full diagnostic criteria) would also be of benefit in determining whether BPD individuals respond differently to emotional material depending on how extreme their level of impairment is.

Personality traits are defined by clinicians as referring to the ways in which a person perceives and relates to other people, thinks about their environment and thinks about themself. Personality traits are stable over time and are demonstrated by people in a variety of social and personal situations. These traits are only considered to be a personality disorder when they are rigid, maladaptive, and cause significant distress or impairment (APA, 2000). Investigations using this population may aid in answering some of the contradictions in the literature, as people exhibiting BPD traits may respond to emotional material in a similar way to BPD patients but may not have the complications of clinical impairment and co-morbid Axis I conditions..

In conclusion, Linehan's (1993) biosocial model of BPD is partially supported by some researchers (e.g., Wagner & Linehan, 1999; Ladisich & Feil, 1988), however more research is needed to clarify the contradiction in the literature in that some researchers have found that BPD patients are more accurate at interpreting emotional information than other people (e.g., Frank & Hoffman, 1986) but other researchers have found that they are less accurate (e.g., Bland et al., 2004) suggesting the need for further investigation into the underlying processes involved in emotional interpretation.

References

Allen, D.M., & Whitson, S. (2004). Avoiding patient distortions in psychotherapy with borderline personality disorder patients. *Journal of Contemporary Psychotherapy, 34,* 211-229.

American Psychiatric Association (2000). *Diagnostic and Statistical Manual of Mental Disorders (4th Ed. Text Revision).* Washington: American Psychiatric Association.

Arntz, A., Appels, C., & Siewerda, S. (2000). Hypervigilance in borderline personality disorder: A test with the emotional stroop paradigm. *Journal of Personality Disorders, 14*, 366-373.

Arntz, J.A., & Veen, G. (2001). Evaluations of others by borderline patients. *The Journal of Nervous & Mental Disease, 189*, 513–521.

Battaglia, M., Strombi, L.F., Bertella, S., Bajo, S., & Bellodi, L. (1999). First-cycle REM density in never depressed subjects with BPD. *Biological Psychiatry, 45,* 1056 – 1058.

Bauer, L.O., & Hesselbrock, V.M. (1999). P300 decrements in teenagers with conduct problems: Implications for substance abuse risk and brain development. *Biological Psychiatry, 46*, 263-272.

Bell, J., Lycaki, H., Jones, D., Kelwala, S., & Sitaram, N. (1983). Effect of pre-existing BPD on clinical and EEG sleep correlates of depression. *Psychiatry Research, 9*, 115 – 123.

Benson, K.L., King, R., Gordan, D., Silva, J.A., & Zarcona Jr., V.P. (1990). Sleep patterns in BPD. *Journal of Affective Disorders, 18*, 267 – 273.

Blackwood, D.H.R., St Clair, D.M., & Kutcher, S.P. (1986). P300 event-related potential abnormalities in BPD. *Biological Psychiatry, 21*, 557-560.

Bland, A.R., Williams, C.A., Scharer, K., & Manning, S. (2004). Emotional processing in borderline personality disorders. *Issues in Mental Health Nursing, 25*, 655-672.

Boutros, N., Nasrallah, H., Leighty, R., Torello, M., Tueting, P., & Olson, S. (1997). Auditory evoked potentials, clinical vs. research applications. *Psychiatry Research, 69*, 183-195.

Boutros, N.N., Torello, M., & McGlashan, T.H. (2003). Electrophysiological aberrations in BPD: State of the evidence. *Journal of Neuropsychiatry and Clinical Neurosciences, 15*, 145-154.

Bradley, M.M., Cuthbert, B.N., & Lang, P.J. (1996). Picture media and emotion: Effects of a sustained affective context. *Psychophysiology, 33*, 662-670.

Calvo, M.G., & Esteves, F. (2005). Detection of emotional faces: Low perceptual threshold and wide attentional span. *Visual Cognition, 12*, 13-27.

Carretié, L., Iglesias, J., & García, T. (1997). A study of the emotional processing of visual stimuli through event-related potentials. *Brain and Cognition, 34*, 207-217.

Chavira, D.A., Grilo, C.M., Shea, M.T., Yen, S., Gunderson, J.G., & Morey, L.C., et al. (2003). Ethnicity and four personality disorders. *Comprehensive Psychiatry, 44*, 483-491.

Cheavens, J.S., Rosenthal, M.Z., Daughters, S.B., Nowak, J., Kosson, D., & Lynch, T.R., et al. (2005). An analogue investigation of the relationships among perceived parental criticism, negative affect and borderline personality disorder features: The role of thought suppression. *Behaviour Research and Therapy, 43*, 257-268.

Clarkin, J.F., Levy, K.N., Lenzenweger, M.F., & Kernberg, O.F. (2004). The personality disorders institute/ borderline personality disorder research foundation randomised control trial for borderline personality disorder: Rationale, methods and patient characteristics. *Journal of Personality Disorders, 18*, 52-72.

Coolidge, F.L., Segal, D.L., Stewart, S.E., & Ellett, J.A. (2000). Neuropsychological dysfunction in children with BPSD features; A preliminary investigation. *Journal of Research in Personality, 34*, 554-561.

Cuthbert, B.N., Schupp, H.T., Bradley, M.M., Birbaumer, W., & Lang, P.J. (2000). Brain potentials in affective picture processing; Covariation with autonomic arousal and affective report. *Biological Psychiatry, 52*, 95-111.

Cuthbert, B.N., Schupp, H.T., Bradley, M., McManis, M., & Lang, P.J. (1998). Probing affective pictures: Attended startle and tone probes. *Psychophysiology, 35*, 344-347.

De la Fuente, J.M., Bobes, J., Vizuete, C., & Mendlewicz, J. (2001). Sleep EEG in borderline patients without concomitant major depression: A comparison with major depressives and normal control subjects. *Psychiatry Research, 105*, 87-95.

De Soto, M.C., Geary, D.C., Hoard, M.K., Sheldon, M.S., & Cooper, L. (2003). Estrogen fluctuations, oral contraceptives and borderline personality. *Psychoneuroendocrinology, 28,* 751-766.

Donchin, E., & Coles, M.H.G. (1988). Precommentary: Is the P300 component a manifestation of context updating? *Behavioural and Brain Sciences, 11*, 357-374.

Drake, M.E., Phillips, B.B., & Pakainis, A. (1991). Auditory evoked potentials in borderline Personality Disorder. *Clinical Electroencephalography, 22*, 188-192.

Driessen, M., Hermann, J., Stahl, K., Zwann, M., Meier, S., & Hill, A., et al. (2000). Magnetic resonance imaging volumes of the hippocampus and the amygdala in women with BPD and early traumatisation. *Archives of General Psychiatry, 57*, 1115-1122.

Ebner-Priemer, U.W., Badeck, S., Beckmann, C., Wagner, A., Feige, B., & Weiss, I., et al. (2005). Affective dysregulation and dissociative experience in female patients with borderline personality disorder: A startle response study. *Journal of Psychiatric Research, 39*, 85-92.

Empson, J. (1986). *Human Brainwaves: The Psychological Significance of the Electroencephalogram.* New York: Stockton Press.

Felmingham, K.L., Bryant, R.A., & Gordon, E. (2003). Processing angry and neutral faces in post-traumatic stress disorder: An event-related potentials study. *Neuroreport, 14*, 777-780.

Figueroa, E., & Silk, K.R. (1997). Biological implications of childhood sexual abuse in borderline personality disorder. *Journal of Personality Disorders, 11*, 71-92.

Fonagy, P. (2000). Attachment and borderline personality disorder. *Journal of the American Psychoanalytic Association, 45*, 1129-1146.

Frank, H., & Hoffman, N. (1986). Borderline empathy: an empirical investigation. *Comprehensive Psychiatry, 27*, 387-395.

Gurrera, R.J., Salisbury, D.F., O'Donnell, B.F., Nestor, P.G., & McCarley, R.W. (2005). Auditory P3 indexes personality traits and cognitive function in healthy men and women. *Psychiatry Research, 133*, 215-228.

Gurvits, I.G., Koenigsberg, H.W., & Siever, L.J. (2000). Neurotransmitter dysfunction in patients with borderline personality disorder. *Psychiatric Clinics of North America. Special Issue: Borderline Personality Disorder, 23*, 27-40.

Guttman, H., & Laporte, L. (2000). Empathy in families of women with borderline personality disorder, anorexia nervosa and a control group. *Family Process, 39*, 345-358.

Ha, K.S., Kim, S.J., Yune, S.K., Kim, J.H., Hwang, J.W., & Lee, N.Y., et al. (2004). Three year follow up of women with and without borderline personality disorder: Development of Cloninger's character in adolescence. *Psychiatry and Clinical Neuroscience, 58*, 42-47.

Hansenne, M., Pitchot, W., Pinto, E., Reggers, J., Scantamburlo, G., & Fuchs, S., et al. (2002). 5-H2-sub (IA) dysfunction in borderline personality disorder. *Psychological Medicine, 32*, 935-941.

Herpertz, S.C., Dietrich, T.M., Wenning, B., Krings, T., Erberich, S.G., & Willmas, K., et al. (2001). Evidence of abnormal amygdala functioning in borderline personality disorder: A functional MRI study. *Biological Psychiatry, 50*, 292-298.

Herpertz, S.C., Kunert, H.J., Schwenger, U.B., & Sass, H. (1999). Affective responsiveness in BPD: A psychophysiological approach. *The American Journal of Psychiatry, 156*, 1550-1556.

Herpertz, S.C., Schwenger, U.B., Kunert, H.J., Lukas, G., Gretzer, U., & Nutzmann, J., et al. (2000). Emotional responses in patients with borderline as compared with avoidant personality disorder. *Journal of Personality Disorders, 14,* 339-351.

Holmes, J. (2003). Borderline personality disorder and the search for meaning: An attachment perspective. *Australian and New Zealand Journal of Psychiatry, 37,* 524-531.

Hooley, J.M., & Hoffman, P.D. (1999). Expressed emotion and clinical outcome in BPD. *The American Journal of Psychiatry, 156,* 1557-1562.

Houston, R.J., Bauer, L.O., & Hesselbrock, V.M. (2004). Effects of borderline personality disorder features and a family history of alcohol or drug dependence on P300 in adolescents. *International Journal of Psychophysiology, 53*, 57-70.

Johnson, P.A., Hurley, R.A., Benkelfat, C., Herpertz, S.C., & Taber, K.H. (2003). Understanding emotion regulation in borderline personality disorder: Contributions of neuroimaging. *The Journal of Neuropsychiatry and Clinical Neurosciences, 15*, 397-402.

Kahl, K.G., Bester, M., Greggersen, W., Rudolf, S., Dibbert, L., & Stoeckelhuber, B.M., et al. (2005). Visceral fat deposition and insulin sensitivity in depressed women with and without comorbid borderline personality disorder. *Psychosomatic Medicine, 67,* 407-412.

Kernberg, O.F. (1984). *Severe Personality Disorders: Psychotherapeutic Therapies.* New Haven, CT: Yale University Press.

Kliegel, M., Horn, A.B., & Zimmer, H. (2003). Emotional after-effects on the P3 component of the event-related brain potential. *International Journal of Psychology, 38,* 129-137.

Korfine, L., & Hooley, J.M. (2000). Directed forgetting of emotional stimuli in borderline personality disorder. *Journal of Abnormal Psychology, 109*, 214-221.

Krolak-Salmon, P., Fischer, C., Vighetto, A., & Mauguiére, F. (2001). Processing of facial emotional expression: Spatio-temporal data as assessed by scalp event-related potentials. *European Journal of Neuroscience, 13*, 987-994.

Kutcher, S.P., Blackwood, D.H.R., Gaskell, D.F., Muir, W.J., & St Clair, D.M. (1989). Auditory P300 does not differentiate BPD from schizotypal personality disorder. *Biological Psychiatry, 26*, 766-774.

Kutcher, S.P., Blackwood, D.H.R., St Clair, D., Gaskell, D.F., & Muir, W.J. (1987). Auditory P300 in BPD and schizophrenia. *Archives of General Psychiatry, 44*, 645-650.

Ladisich, W., & Feil, W.B. (1988). Empathy in psychiatric patients. *British Journal of Medical Psychiatry, 61*, 155-162.

Lahmeyer, H.W., Reynolds, C.F., Kupfer, D.J., & King, R. (1989). Biologic markers in BPD: A review. *Journal of Clinical Psychiatry, 50*, 217-225.

Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (1999). *International Affective Picture System (IAPS): Instruction Manual and Affective Ratings.* University of Florida, USA: The Centre for Research in Psychophysiology.

Lenzenweger, M.F., Clarkin, J.F., Fertuck, E.A., & Kernberg, O.F. (2004). Executive neurocognitive functioning and neurobehavioural systems indicators in borderline personality disorder: A preliminary study. *Journal of Personality Disorders, 18*, 421-438.

Levine, D. (1992). Adult emotional development; A comparison of emotion processing in borderline personality disorders and non-borderline subjects. *UMI Dissertation Services.* Ann Arbor, Michigan: Bell & Howell Company.

Levine, D., Marziali, E., & Hood, J. (1997). Emotion processing in BPDs. *The Journal of Nervous and Mental Disease, 185*, 240-246.

Levy, K.N., Meehan, K.B., Weber, M., Reynoso, J., & Clarkin, J.F. (2005). Attachment and borderline personality disorder: Implications for psychotherapy. *Psychopathology, 38*, 64-74.

Lincoln, A.J., Bloom, D., Katz, M., & Boksenbaum, N. (1998). Neuropsychological and neurophysiological indices of auditory processing impairment in children with multiple complex developmental disorder. *Journal of the American Academy of Child and Adolescent Psychiatry, 37*, 100-112.

Linehan, M.M. (1993). *Cognitive-Behavioural Treatment of Borderline Personality Disorder*. New York: Guilford Press.

McCarley, R.W., Shenton, M.E., O'Donnell, B.F., Faux, S.F., Kilkinis, R., & Nestor, P.G., et al. (1993). Auditory P300 abnormalities and left posterior superior temporal gyrus volume reduction in schizophrenia. *Archives of General Psychiatry, 50*, 190-197.

McNamara, E., Reynolds, C.F., Soloff, P.H., Mathias, R., Rossi, A., & Spiker, D., et al. (1984). EEG sleep evaluation of depression in borderline patients. *American Journal of Psychiatry, 141*, 182-186

Meares, R., Melkdenian, D., Gordon, E., & Williams, L. (2005). Distinct pattern of P3a event-related potential in borderline personality disorder. *Neuroreport, 16*, 289-293.

Minzenberg, M.J., Fisher-Irving, M., Poole, J.H., & Vinogradov, S. (2006). Reduced self-referential source memory performance is associated with interpersonal dysfunction in borderline personality disorder. *Journal of the Personality Disorders, 20*, 42-54.

Meyer, B., Pilkonis, P.A., & Boevers, C.G. (2004). What's in a (neutral) face? Personality disorders, attachment styles, and the appraisal of ambiguous social cues. *Journal of Personality Disorders, 18*, 320-336.

Millon, T. (2000). Sociocultural conceptions of the borderline personality. *Psychiatric Clinics of North America. Special Issue: Borderline Personality Disorder, 23*, 123-136.

Norra, C., Mrazek, M., Tuchtenhagon, F., Gobbele, R., Buchner, H., & Sab, H., et al. (2003). Enhanced intensity dependence as a marker of low serotonergic neurotransmission in BPD. *Journal of Psychiatric Research, 37*, 23-33.

O'Leary, K.M., Brouwers, P., Gardner, D.L., & Cowdry, R.W. (1991). Neuropsychological testing of patients with BPD. *The American Journal of Psychiatry, 148*, 106-111.

Oquendo, M.A., Krunic, A., Parsey, R.V., Milak, M., Malone, K.M., & Anderson, A., et al. (2005). Positron emission tomography of regional brain metabolic responses to a serotonergic challenge in major depressive disorder with and without borderline personality disorder. *Neuropharmacology, 30*, 1163-1172.

Pally, R. (2002). The neurobiology of borderline personality disorder: The synergy of "nature and nurture". *Journal of Psychiatric Practice, 8*, 133-142.

Paris, J. (1993). The treatment of borderline personality disorder in light of the research on its long term outcome. *Canadian Journal of Psychiatry, 38*, 28-34.

Paris, J. (1996). Cultural factors in the emergence of borderline pathology. *Psychiatry: Interpersonal and Biological Processes, 59*, 185-192.

Paris, J. (2002). Clinical practice guidelines for borderline personality disorder. *Journal of Personality Disorders, 16*, 107-108.

Paris, J. (2005). Borderline personality disorder. *Canadian Medical Association Journal, 172,* 1579-1583.

Paris, J., & Zweig-Frank, H. (2001). The 27 year follow up of patients with borderline personality disorder. *Comprehensive Psychiatry, 42*, 482-487.

Parker, S.W., & Nelson, C.A. (2005). The impact of early institutional rearing on the ability to discriminate facial expressions of emotion: An event-related potential study. *Child Development, 76*, 54-72.

Picton, T.W. (1992). The P300 wave of the human event-related potential. *Journal of Clinical Neurophysiology, 9*, 456-479.

Pinto, C., Dhavale, H.S., Nair, S., Patil, B., & Delwan, M. (2000). BPD exists in India. *The Journal of Nervous and Mental Disease, 188*, 386-388.

Pollack, S.D., Klorman, R., Thatcher, J.E., & Cicchetti, D. (2001). P3b reflects maltreated children's reactions to facial displays of emotion. *Psychophysiology, 38*, 267-274.

Porjesz, B., & Begleiter, H. (1998). Genetic basis of event-related potentials and their relationship to alcoholism and alcohol use. *Journal of Clinical Neurophysiology, 15*, 44-57.

Reynolds, R.F., Soloff, P.H., Kupfer, D.J., Taska, L.S., Restifo, K., & Coble, P.A., et al. (1985). Depression in borderline patients: A perspective EEG sleep study. *Psychiatry Research, 14*, 1-15.

Rosler, F. (1983). Endogenous ERPs and cognition: Probes, prospects, and pitfalls in matching pieces of the mind-body puzzle. In A.W.K Galliard, & W. Ritter (Eds.), *Tutorial in Event-Related Potential Research: Endogenous Components* (pp.1-35). Amsterdam: North-Holland Press..

Sanislow, C.A., Grilo, C.M., Morey, L.C., Bender, D.S., Skodol, A.E., & Gunderson, J.G., et al. (2002). Confirmatory factor analysis of DSM-IV criteria for borderline personality disorder: Findings from the collaborative longitudinal personality disorders study. *American Journal of Psychiatry, 59*, 284-290.

Sansone, R.A., & Levitt, J.L. (2005). Borderline personality and eating disorders. *Eating Disorders, 13*, 71-83.

Schmahl, C.G., Vermetten, E., Elzinga, B.M., & Bremner, J.D. (2003). Magnetic resonance imaging of hippocampal and amygdala volume in women with childhood abuse and borderline personality disorder. *Psychiatry Research: Neuroimaging, 122*, 193-198.

Schupp, H.T., Junghöfer, M., Weike, A.I., & Hamm, A.O. (2003). Attention and emotion: An ERP analysis of facilitated emotional stimulus processing. *Neuroreport, 14*, 1107-1110.

Semerari, A., Carcione, A., Dimaggio, G., Nicolò, G., Pedore, R., & Procacoi, M. (Metarepresentative function in borderline personality disorder. *Journal of Personality Disorders, 19*, 690-710.

Siever, L.J., Torgersen, S., Gunderson, J.G., Livesley, W.J., & Kendler, K.S. (2002). The borderline diagnosis III: Identifying endophenotypes for genetic studies. *Biological Psychiatry, 51*, 964-968.

Skodol, A.E., & Bender, D.S. (2003). Why are women diagnosed borderline more than men? *Psychiatric Quarterly. Special Issue: The Fifteenth Annual New York State Office of Mental Health Research Conference, 74*, 349-360.

Skodol, A.E., Gunderson, J.G., Pfohl, B., Widiger, T.A., Livesley, W.J., & Siever, L.J. (2002). The borderline diagnosis I: Psychopathology, comorbidity and personality structure. *Biological Psychiatry, 51*, 936-950.

Smith, D.P., Hillman, C.H., & Duley, A.R. (2005). Influence of age on emotional reactivity during picture processing. *The Journals of Gerontology, 60B*, 49-56.

Stone, M.H. (1990). *The Fate of Borderline Patients: Successful Outcome and Psychiatric Practice.* New York: Guilford Press.

Terbartz van Elst, L., Hesslinger, B., Thiel, T., Geiger, E., Haegele, K., & Lemieux, L., et al. (2003). Frontolimbic brain abnormalities in patients with borderline personality disorder: A volumetric magnetic resonance imaging study. *Biological Psychiatry, 54,* 163-171.

Terbartz van Elst, L., Thiel, T., Hesslinger, B., Lieb, K., Bohus, M., & Hennig, J., et al. (2001). Subtle prefrontal neuropathology in a pilot magnetic resonance spectroscopy study in patients with BPD. *The Journal of Neuropsychiatry and Clinical Neurosciences, 13*, 511-514.

Torgersen, S. (1987). Sampling problems in twin research. *Journal of Psychiatry Research, 21*, 385-390.

Torgersen, S. (2000). Genetics of patients with borderline personality disorder. *Psychiatric Clinics of North America, Special Issue: Borderline Personality Disorder, 23*, 1-9.

Trull, T.J., Stepp, S.D., & Durrett, C.A. (2003). Research on BPD: An update. *Current Opinion in Psychiatry, 16*, 77-82.

Wagner, A.W., & Linehan, M.M. (1999). Facial expression recognition ability among women with BPD: Implications for emotion regulation? *Journal of Personality Disorders, 13*, 329-344.

Westen, D. (1991). Cognitive-behavioural interventions into psychoanalytic psychotherapy of borderline personality disorders. *Clinical Psychology Review, 11*, 211-230.

Yen, S., Zlotnick, C., & Costello, E. (2002). Affect regulation in women with BPD traits. *The Journal of Nervous and Mental Disease, 190,* 693-696.

Zimmerman, M., & Mattia, J.I. (1999). Differences between clinical and research practices in diagnosing borderline personality disorder. *The American Journal of Psychiatry, 156*, 1570-1574.

Empirical Study

Borderline Personality Traits and Emotion Processing: An Event-Related Potentials Study

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Abstract

The biosocial model of Borderline Personality Disorder (BPD; Linehan, 1993) proposes that BPD patients respond with a heightened sensitivity to emotional information. To investigate this theory, the event-related potentials (ERPs) of 15 female university students endorsing BPD traits (BPT), but not having a diagnosis of BPD, were recorded for emotional pictures (International Affective Picture System; Lang, Bradley, & Cuthbert, 1999) and faces (Pictures of Facial Affect; Ekman & Friesen, 1976) and compared to a control group of 15 female students who did not endorse BPD traits. In support of the biosocial model, the BPT group were found to respond differently to emotional material than controls, with shorter P300 and LPC latencies when making incorrect and correct responses and smaller LPC and P300 amplitudes when making incorrect responses. These results were interpreted as reflecting weakened attentional resources being applied to emotional processing by the BPT group.

Numerous researchers (e.g., Linehan, 1993; Westen, 1991) perceive the diagnostic behaviours of Borderline Personality Disorder (BPD; e.g., interpersonal problems, suicidal gestures, emotional instability, and impulsive actions) to be a direct function of the BPD patients' inability to regulate their emotions to the emotional cues in their environment accurately. Clinicians working with BPD patients have observed that these individuals often display both intense and minute emotional reactions to highly arousing events (Figueroa & Silk, 1997). Patients with BPD may therefore have difficulty appraising emotional information correctly, possibly through errors of attention or misinterpretation of emotional cues, and thus respond to emotional information differently to other people (Dodge, 1991).

Supporting the notion of misinterpretation of emotional cues, Linehan's (1993) biosocial theory of BPD proposes that BPD patients possess a fundamental vulnerability to emotional information. BPD patients are viewed as having a high sensitivity to emotional stimuli in their environment (especially negative emotional cues), coupled with a low threshold for emotional reactivity and they therefore exhibit a quicker than average response to emotional cues, specifically those that are negative in nature. Linehan believes that this emotional vulnerability is partly biologically based but exacerbated by exposure as a developing child to an 'invalidating environment'. An invalidating environment is understood as being an environment in which a child is taught that his or her emotional reactions are invalid, wrong, or somehow faulty.

Earlier investigations into empathy in BPD have provided evidence for a heightened sensitivity to emotional information in BPD patients. Frank and Hoffman

(1986) compared the responses of 10 participants diagnosed with BPD and 14 participants who did not meet the diagnostic criteria to a series of video-taped vignettes. Participants were asked to identify the emotional content of each vignette as being either positive or negative and the BPD group were found to be more accurate at identifying both positive and negative emotions than the participants without BPD. In another study, involving the correspondence between a participant's self-assessment and their assessment of others (Ladisich & Feil, 1988), it was found that BPD patients were more accurate than other psychiatric groups at assessing other people's emotional states.

The results of a further study involving recognition of emotional facial expressions suggest that patients with BPD may respond differently to emotional cues than people without BPD. Wagner and Linehan (1999) compared the performance of participants with a diagnosis of BPD who had a history of childhood sexual abuse (BPD: n = 21), a group of participants with a history of childhood sexual abuse, who did not meet the diagnostic criteria for BPD (CSA: n = 21), and a control group of participants who did not meet the criteria for a diagnosis of BPD or have a history of childhood sexual abuse (n = 20) on a facial recognition task. In comparison to both the control and CSA groups, the BPD group were found to be more accurate at identifying fear facial expressions but they also tended to respond to neutral faces negatively by assigning the emotion of fear to non-fear faces. This led the researchers to conclude that BPD patients may be just as skilled at recognising basic emotional expressions as other people however they may be disposed to misinterpret facial expressions more negatively. This research thus provided partial support for

Linehan's (1993) biosocial theory as the BPD patients were found to be just as accurate at recognising basic emotions as other people but they were also found to be less accurate, with a tendency to ascribe negative emotions, when the faces were neutral.

Other studies employing facial expressions of emotion have not supported the biosocial theory as they have found that BPD patients are less accurate at identifying emotions than other people. Levine, Marziali, and Hood (1997) presented emotional facial expression pictures to 30 female participants who met the criteria for BPD and 40 participants who did not and found that the BPD group were less accurate at recognising facial expressions, reported more intense responses to unpleasant emotions, and had significantly lower levels of emotional awareness than the group without BPD. Furthermore, in a study conducted by Bland, Williams, Scharer, and Manning (2004) individuals diagnosed with BPD were shown to be less accurate than other people at identifying facial expressions of sadness, anger, and disgust. There is thus a contradiction in the literature, where some researchers have found that BPD patients are more accurate at identifying emotions than other people and other researchers have found that they are less accurate, or more specifically less accurate with negative emotional information.

Event-Related Potentials (ERPs) may provide a useful tool for examining the neuropsychological basis for differences in emotional information processing in BPD patients and solving the contradiction in the literature. ERPs are extracted by averaging electroencephalographic (EEG) recordings of brain activity taken from the cerebrum while an individual performs a cognitive task (Empson, 1986). These evoked potentials are useful in identifying the cortical processes involved in attention, recognition, and information processing (Lincoln, Bloom, Katz, & Boksenbaum, 1998).

Early investigations examining the ERPs of BPD patients were primarily concerned with exploring the association between BPD and depression, schizophrenia, and schizophrenia-spectrum disorders (Boutros, Torello, & McGlashan, 2003). Using auditory elicited ERPs, Blackwood, St Clair, and Kutcher (1986) reported significantly smaller amplitude and longer latency P300 (a positive ERP component occurring approximately 300msecs after identification of a low probability stimulus) in a group of BPD patients (n = 14) compared to a group of psychiatric patients not diagnosed with BPD and a group of participants who did not have a mental illness. Further studies by Kutcher, Blackwood, St Clair, Gaskell, and Muir (1987) and Kutcher, Blackwood, Gaskell, Muir, and St Clair (1989) compared the ERPs of different psychiatric patient groups and found this pattern of low P300 amplitude and prolonged P300 latency differentiated individuals with BPD, schizophrenia, and schizotypal personality disorder from participants with major depression, participants with a personality disorder other than BPD, and participants without a mental illness.

Few investigations have examined the ERPs of BPD patients with visual stimuli. Houston, Bauer, and Hesselbrock (2004) measured the ERPs of 175 males and females, who were categorised into either a BPD (n = 87) or non-BPD group (n = 88) based on the number of BPD features they endorsed. Participants were then administered the Stroop colour word test and the BPD group were found to have smaller P300 amplitude and poorer response accuracy than the non-BPD group. However, it must be noted that these differences in ERP patterns were found for non-emotional stimuli.

Research employing ERPs to further understand emotional processing (Bradley, Cuthbert, & Lang, 1996) has shown that participant's take longer to process or look at both pleasant and unpleasant emotional content pictures than neutral emotional content pictures suggesting that emotionally arousing pictures (either pleasant or unpleasant) require more attentional resources to process than neutral pictures. In addition, larger P300 amplitude and longer latency has been shown for unpleasant and pleasant emotional pictures in comparison to neutral pictures and a larger response to pleasant and unpleasant stimuli has been demonstrated in the right hemisphere than in the left (Keil et al., 2002). These differences in response to emotionally rich stimuli have been explained by Lang, Bradley, and Cuthbert (1990) as being due to motivationally relevant stimuli naturally and unconsciously arousing and directing more attentional resources than motivationally irrelevant stimuli (e.g., neutral emotional information).

Another element of the ERP that has been shown to vary as a function of emotional valence is the late positive component (LPC) of the wave form (Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000). The LPC can be distinguished from the P300, as it appears later (400 – 600 ms post stimulus onset) and when responding to emotional stimuli, is greater in amplitude in the right than left parietal hemisphere (Cuthbert et al., 2000). Studies examining ERP responses to emotional material have found LPC amplitude to be larger and latency longer to pleasant and unpleasant pictures than to neutral pictures, with responses to pleasant and unpleasant pictures being similar in amplitude and latency (Carretié, Iglesias, & García, 1997; Schupp, Junghöfer, Weike, & Hamm, 2003).

In order to gain a more comprehensive understanding of emotional processing, other ERP studies have examined reactions to emotional facial expressions, rather than pictures containing a general emotional content, as facial recognition is believed to elicit brain responses that are different to those involved in other types of information processing (Balconi & Lucchiari, 2005). Holmes, Vuilleumier, and Eimer (2003) found that P300 amplitude was greater when processing faces than when processing other types of stimuli (e.g., houses) and LPC amplitude has been found to be greater to attractive than non-attractive faces (Johnston & Oliver-Rodriguez, 1997). In addition, researchers have found that happy faces elicit a larger right hemisphere response and neutral faces a larger left hemisphere response (Graham & Cabeza, 2001) and differences in response have also been found for pleasant and unpleasant facial expressions compared to neutral facial expressions (Krolak-Salmon, Fischer, Vighetto, & Mauguiére, 2001).

The current study aimed to investigate the neuropsychological basis for an emotional dysregulation theory of BPD (e.g., Linehan, 1993) by using ERPs to examine the processes involved in the appraisal of emotional stimuli by individuals exhibiting BPD traits (BPT) but who do not meet the full diagnostic criteria for BPD. The study specifically examined whether BPT individuals are more sensitive to emotional material than participants who did not endorse BPD traits (controls), whether there are differences in the ERP responses to emotional material between

BPT and controls, and lastly, whether BPT individuals are more likely to perceive neutral emotional stimuli as being negative than controls. The contradiction in the literature where some researchers have found BPD patients to be more accurate at identifying emotions (e.g., Frank & Hoffman, 1986) while other researchers have found BPD patients to be less accurate (e.g., Levine et al., 1997) will also be examined.

Individuals endorsing BPT traits were examined, rather than those meeting the full diagnostic criteria for BPD, for a number of reasons. Firstly, earlier research involving BPD patients has been confounded by medication issues, as many BPD patients may be taking prescription psychotropic medication for BPD symptoms or for a co-morbid Axis I condition (Boutros et al., 1997). Secondly, it is widely reported that other Axis I conditions co-occur with BPD (e.g., depression) and some studies have not controlled for this adequately (e.g., Clarkin, Levy, Lenzeweger, & Kernberg, 2004). Thirdly, it would be useful to investigate whether these differences in emotional sensitivity and ERP responses to emotional material are visible in people who exhibit traits of BPD but who do not meet the full diagnostic criteria.

It was hypothesised that BPT individuals would be more sensitive to both pleasant and unpleasant emotional stimuli than controls (as measured by shorter reaction times and greater response accuracy). This hypothesis is based on Linehan's (1993) biosocial theory which predicts that BPD patients are more sensitive to emotional information than people without BPD. It was also expected that this greater emotional sensitivity would be reflected in the BPT group's ERP responses, with the BPT group exhibiting shorter P300 latency and greater P300 amplitude than the control group. Although previous researchers using non-emotional stimuli (e.g., Houston et al., 2004) found smaller amplitudes and longer latencies in BPD patients than other people, it was expected that the ERP responses in this study would be shorter for emotional stimuli and that they would reflect a heightened sensitivity to emotional stimuli.

Following on from previous research (e.g., Wagner & Linehan, 1999), it was predicted that BPT individuals would be more likely to ascribe a negative emotional valence to neutral emotional stimuli than controls, as indicated by decreased response accuracy to the neutral stimuli, in comparison to the pleasant and unpleasant stimuli. Furthermore, it was predicted that the control group would exhibit longer reaction times and later P300 and LPC latency and greater amplitude LPC to both the unpleasant and pleasant emotional stimuli than the neutral stimuli, as found by past research (e.g., Bradley et al., 1996) and predicted based on the theory that BPD patients are more sensitive to emotional material than people without BPD (e.g., Linehan, 1993). However, it was expected that the BPT group would respond to the neutral stimuli with similar P300 and LPC latency and amplitude as to the pleasant and unpleasant stimuli, because of the aforementioned tendency of BPD patients to interpret neutral emotional information as being negative.

Responses to two different types of stimuli were examined; emotional facial expressions and pictures depicting a general emotional theme. It was predicted that the BPT group would be more sensitive to the face slides than the picture slides reflected by greater response accuracy, shorter reaction times, shorter LPC and P300 latency, and greater LPC and P300 amplitude because of their aforementioned tendency to be accurate at identifying other people's emotional states (e.g., Frank & Hoffman, 1986) but that this accuracy would not apply to neutral stimuli, in which it was expected that they would be less accurate. The BPT group were predicted to be more sensitive to the face slides than the picture slides because of the tendency of BPD patients to be more sensitive to emotional material in an interpersonal context and to experience difficulties in their interpersonal relationships (e.g., Linehan, 1993). In contrast, it was expected that the control group would respond with a similar different response pattern to the faces and the pictures but that they would be less sensitive than the BPT group, exhibiting a longer reaction time, less accuracy, longer LPC and P300 latency and smaller P300 and LPC amplitude.

Method

Participants

Participants were 30 female first year psychology students enrolled at the University of Tasmania, aged 18 to 35 years. Males were excluded from this research because firstly, sex differences have been found in ERP responses (Lang et al., 1997), secondly, borderline traits have generally been found to occur more frequently in females than in males (American Psychiatric Association; APA, 2000), and thirdly, males and females have been found to interpret emotional information differently (Mufson & Nowicki, 1991). Age was restricted to 18 to 35 years, because borderline pathology has been shown to change with age (Wagner & Linehan, 1999) and ERPs have also been found to alter with increasing maturity (Smith, Hillman, & Duley, 2005).

Fifteen participants endorsing a high number of items (score = >7) on the McLean Screening Instrument for Borderline Personality Disorder (MSI-BPD; Zanarini et al., 2003; see Appendix A) were recruited to form the Borderline Personality Trait (BPT) group, and 15 participants endorsing a low number of items (score = <2) were recruited to form the Control group. A cut off score of seven or more was used as Zanarini et al. (2003) state that it is the optimal score to use because it has been found to have high sensitivity (0.81) and specificity (0.85) at differentiating those people who have BPD from those who do not. In addition, participants were administered the Millon Clinical Multiaxial Inventory-III (MCMI-III; Millon, Davies, & Millon, 1997; see Appendix B), and those participants' who obtained a clinically significant score on any MCMI - III scale other than the borderline scale if they were in the BPT group were omitted from further testing (Base rate score >85). Membership into the BPT group was also controlled by excluding individuals who obtained a high score on the MSI-BPD screener but a low score on the borderline scale of the MCMI-III. Means for participants' scores on the MSI-BPD and mean ages can be seen in Table 1. Overall 232 psychology students were administered screeners in order to select participants for the two groups.

Table 1. Mean Scores (Standard Deviations in parentheses) for the Control and BPT Groups Responses to the MSI-BPD and Mean Ages.

	Control		BPT	
MSI-BPD Mean Score	0.7	(0.52)	8.3	(0.87)
Mean Age (years)	23.1	(4.32)	22.5	(3.46)

Prior to experimentation all participants also completed a medical questionnaire (see Appendix C) and were excluded from further involvement in the research if they had recently smoked cannabis, used other illicit substances, were heavy smokers or binge drinkers, or had experienced a head injury. All participants possessed normal or corrected to normal vision and were right-handed.

Initial care was taken to exclude participants who were taking prescription medication however, as with any research involving participants displaying borderline symptomatology difficulties arose recruiting participants who had no co-morbid depression, accordingly, six participants in the BPT group were included who were currently being prescribed an anti-depressant (see Appendix D for details). No significant differences were found between the BPT participants' scores on the scale relating to depression on the MCMI-III as a function of anti-depressant medication. Mean scores and standard deviations for the control and BPT (medicated and no medication) groups responses to the MCMI-III can be seen in Table 2. Behavioural task performance (e.g., reaction time and accuracy) was also found to be unaffected by medication use.

In general for ERP responses, medication was found to have little effect, however, some differences were found for coronal sites, with a significant interaction being found between Group and Coronal sites for P300 amplitude for correct responses to faces, $F(4, 52) = 3.627$, $MSE = 64.05$, $p = .03$, and a significant three-way interaction between Stimulus, Group and Coronal sites for LPC amplitude for incorrect responses to pictures, $F(4, 52) = 3.23$, $MSE = 30.26$, $p = .03$. Breakdown ANOVAs by Stimulus showed no theoretically significant effects. Covariate analysis would not have been appropriate since there were only six participants in the medication group and in addition, whether participants were on medication or not was a categorical variable. Hence, the medicated participants were included in the BPT group.

Table 2. Mean (M) and Standard Deviation (SD) Scores for the Control (n = 15), BPT Not on Medication (n = 9) and BPT with Medication (BMED: n = 6) Groups Responses to the MCM-III.

MCMI Scale	Control		BPT		BMED	
	M	SD	M	SD	M	SD
Schizoid	26.67	16.33	30.44	18.67	28.43	17.24
Depressive	13.20	20.80	20.78	25.60	21.50	22.25
Avoidant	18.33	16.16	24.89	16.38	22.17	16.22
Dependent	31.13	24.75	32.22	12.69	33.40	13.14
Histrionic	40.33	24.58	40.11	15.06	41.67	20.88
Narcissistic	39.07	15.34	38.33	23.21	39.17	22.03
Antisocial	28.13	26.02	29.67	28.39	29.00	13.01
Sadistic	24.50	21.38	18.68	3.56	11.00	10.75
Compulsive	44.80	14.57	49.78	22.17	41.33	15.95
Masochistic	9.60	17.68	40.78	20.01	31.17	33.70
Negativistic	10.67	18.61	36.89	13.02	35.00	14.04
Borderline	1.60	3.31	79.78	22.57	75.67	12.61
Schizotypal	12.00	22.10	26.56	15.82	23.50	19.51
Paranoid	15.80	25.16	22.00	24.16	23.83	4.62
Somatoform	7.53	13.39	19.56	22.69	20.17	30.64
Anxiety	26.20	31.72	33.78	13.60	32.83	24.90
Bipolar	26.27	20.38	28.56	27.40	30.83	9.22
Alcohol Dependence	19.47	27.00	28.56	31.62	23.67	3.23
Dysthymia	4.93	6.38	11.78	24.50	17.17	28.39
Drug Dependence	27.40	27.51	34.89	33.43	29.17	18.76
PTSD	11.33	19.22	16.11	22.19	17.83	13.93
Thought Disorder	6.87	11.29	20.11	10.25	19.83	17.12
Delusional Disorder	9.67	19.59	16.44	18.20	17.83	16.98
Major Depression	5.60	7.17	19.44	20.22	18.83	36.51
Desirability	56.33	12.70	43.67	16.55	44.50	16.29
Debasement	23.47	20.28	57.33	10.90	45.67	15.10

Apparatus

The face and picture tasks were presented on a Neuroscan STIM computer. Electroencephalographic (EEG) and electroculographic (EOG) data were recorded continuously using a Neuroscan SCAN 4.3 computer and a 32 channel Quickcap with Ag/AgCl electrodes.

EEG Recording

The EEG data was amplified at 200Hz and was sampled continuously at 500Hz. Continuous data was corrected for EOG activity and averages were computed over stimulus and response type and group for a 1100ms epoch, beginning at 100ms prior to stimulus onset. Trials that contained artefacts above 150μV were removed from the averages and epochs were low pass filtered at 30Hz and base line corrected.

Stimuli

The stimuli for the picture task consisted of 30 pleasant, 30 unpleasant and 140 neutral pictures taken from the *International Affective Picture Series* (IAPS; Lang, Bradley, & Cuthbert, 1999). Pictures were selected that have been consistently shown to be rated neutral, pleasant or unpleasant by females aged 18-45 in previous research (e.g., Bradley & Lang, 1994; Greenwald, Cook, & Lang, 1989). Pleasant pictures depicting an erotic or food-based image were excluded to account for the association widely reported between borderline pathology and sexual abuse and eating disorders (Sansone & Levitt, 2005), however unpleasant pictures depicting human bodies after accidents and attacks were still included as these were not considered to depict themes that would arouse more intense emotions in BPD participants than in controls. One hundred and four pictures were presented more than once as the number of pictures left after the exclusion was too small for a single presentation and this was randomised by the computer program (see Appendix E for a list of pictures). The pictures varied in levels of arousal (see Appendix E for mean arousal and valence ratings for each picture), with the unpleasant pictures generally being rated more arousing. The emotions were posed by both males and females in the IAPS slides (16 posed by females, 20 posed by males) but this should not have effected the participants' responses as only those pictures rated consistently by the female sample as being neutral, pleasant or unpleasant were included.

The face task consisted of 200 pictures of facial expressions (30 pleasant; 30 unpleasant; 140 neutral) taken from Ekman and Friesen's (1976) *Pictures of Facial Affect* inventory. Unpleasant faces depicted the emotions of anger and fear, pleasant faces expressed the emotion of happiness and neutral faces displayed no emotion (see Appendix E for a list of faces). All the face slides were presented more than once as there were not enough relevant stimuli for a single presentation and this was randomised by the computer program.

Procedure

Ethical approval was obtained prior to experimentation for this study from the Human Research Ethics Committee (Tasmania) Network. After completing the MSI-BPD, eligible participants were contacted by phone and the medical questionnaire was administered. If participants complied with the medical criteria a testing session was then arranged.

At the testing session, following informed consent (see Appendix F for consent and information forms), participants were fitted with the electrode Quickcap and sites F8, F4, Fz, F3, F7, T8, Afz (ground), C4, Cz, C3, T7, P4, Pz, P3, P7, and P8 were filled with electrode gel. Electrodes were also placed above and below each participant's right eye to monitor EOG activity and EEG signals were referenced to electrodes placed on the mastoids behind each ear. All impedance values were kept at or below 10 KΩ.

Following electrode attachment, participants were seated at a computer in a sound attenuated room and presented with a trial of either the picture or face task. The presentation order of the tasks was counterbalanced and a practice trial of each task was provided to allow familiarity with the response pad to occur. Participants were instructed to press "1" unpleasant, if they thought that the picture or face that they were viewing possessed an unpleasant emotional theme (e.g., anger, fear or disgust), "2" neutral, if they felt the face or picture depicted no emotional theme or they were undecided what emotion the slide made them feel and "4" pleasant, if they decided the slide that they were viewing portrayed a pleasant emotional theme (e.g., happiness, love, or contentment). It was expected that response times might be slower to the neutral pictures given that in some cases the participant would press this button if they were undecided. Responses were limited to the buttons "1", "2" and "4" as the keypad featured four buttons. The decision to use these three buttons and not number "3" was based on the way the participants' fingers rested on the box, as it was shown to be more comfortable to use the first three fingers of the left or right hand, to press these buttons than to use button number "3".

Participants were warned that some slides would be presented more than once and were asked to respond to every slide as though it was the first time that they had viewed it. Each slide was presented individually for the duration of 400ms, with an ISI of 1500ms and a response window of 2500ms. Allocation to levels of the factor 'Stimulus' was based on the participants' classification. On completion of the two tasks, participants were provided with a copy of the MCMI-III to complete and participants were excluded from further analyses if they did not meet the aforementioned MCMI-III criteria.

Design

The experiment followed a 2[Group: BPT, control] x 2(Task: picture, face) x 3(Stimulus: unpleasant, neutral, pleasant) mixed factorial design. Two additional repeated measures variables were added for the ERP analyses, Sagittal (frontal, central, parietal) and Coronal (far left, left, midline, right, far right) sites. The dependent variables for the ERP data were P300 and LPC amplitudes and latencies and the dependent variables for the behavioural data were reaction time and accuracy (percentage score for correct or incorrect identification of emotional theme).

Data Analysis

Means and standard deviations were calculated for the behavioural data for correct response reaction time to the three stimulus types. As this experiment used an oddball paradigm for the accuracy data, the number of correct or incorrect responses that participants made to the slides in each task was converted to a percentage score to allow comparisons between responses to each stimulus type. Accordingly for the accuracy data, means and standard deviations were calculated for the percentage of correct responses made to the three types of stimuli (pleasant slide-pleasant response, neutral slide-neutral response, unpleasant slide-unpleasant response) and for the percentage of incorrect responses made to the neutral stimuli (neutral slide-unpleasant response, neutral slide-pleasant response). A three-way mixed ANOVA with Group [BPT, control] as the between groups factor and Task (picture, face) and Stimulus (unpleasant, neutral, pleasant) as the within subjects factors was used to analyse the behavioural data for correct responses and a three-way mixed ANOVA with Group as the between groups factor and Task and Stimulus (neutral-unpleasant response, neutral-pleasant response) as the within subjects factors was used to analyse the incorrect responses.

ERP waveforms for correct responses to unpleasant, neutral, and pleasant slides and incorrect pleasant and unpleasant responses to neutral slides for each Group [BPT, control] and Task (face, picture) were scored for peak amplitude and latency. P300 was calculated as the maximum amplitude between 200 to 400ms post stimulus onset and LPC was calculated between 400 to 700ms. Means and standard deviations were calculated for correct responses to each Stimulus and for incorrect unpleasant and pleasant responses to the neutral slides for each Task and Group over each Sagittal and Coronal site. The means and standard deviations for each ERP component's amplitudes and latencies were assessed using five-way mixed

ANOVAs, with Group [BPT, control] as the between groups factor, and Task (picture, face), Stimulus (unpleasant, neutral, pleasant/neutral-unpleasant response, neutral-pleasant response), Sagittal (frontal, central, parietal) and Coronal (far left, left, midline, right, far right) as the within subjects factors. Data from six participants (two from the BPT group, four from the Control group) were excluded from the incorrect response analysis as they did not make an incorrect pleasant or unpleasant response to the neutral slides in the face task.

For all analyses, the significance level was set at 0.05 and Greenhouse-Geisser corrections were applied to correct for type 1 errors. Significant two- and three-way interactions were followed up using breakdown ANOVAs and pairwise comparisons with a Bonferroni adjusted alpha level were used to further explain significant main effects.

Results

Behavioural data

Reaction Time: The three-way mixed ANOVA conducted on the reaction time data for correct responses showed a significant main effect for Stimulus, $F(2,112) = 3.66$, $MSE = 0.01$, $p<.05$. A significant main effect was also found for Task, $F(1,56) = 24.62$, $MSE = 0.01$, $p<.001$, however, no significant differences were found in reaction time as a function of Group, $F(1,28) = 0.01$, $MSE = 0.09$, $p>.05$.

The significant main effects of Stimulus and Task were modified by a significant two-way interaction between Stimulus and Task, $F(2,112) = 9.27$, $p<.001$. As can be seen in Figure 1, and confirmed by breakdown ANOVAs, for the face task there was a significant main effect of Stimulus, $F(2,56) = 4.29$, $MSE = 42.29$, $p<.05$, with pairwise comparisons indicating that participants responded significantly more slowly to the unpleasant faces ($M = 0.82$ms.) than the pleasant ($M = 0.74$ms) and neutral ($M = 0.74$ms.) faces (p<.001). However, for the picture task no significant differences were found in participants' reaction times to the different picture types, $F(2,56) = 0.47$, $MSE = 0.01$, $p>.05$. No interactions involving group reached significance.

Accuracy: Correct Responses: The three-way mixed ANOVA conducted on participants' correct responses to the faces and pictures showed a significant main effect for Stimulus, $F(2,56) = 17.23$, $MSE = 591.44$, $p<.001$. Pairwise comparisons indicated that overall both groups made significantly more correct responses to the pleasant ($M = 83.62$) and unpleasant ($M = 78.11$) pictures and faces, than to the neutral pictures and faces ($M = 58.80$). Neither the main effect of Group, $F(1,28) = 2.96$, $MSE = 594.95$, $p>.05$, nor Task, $F(1,28) = 1.00$, $MSE = 358.95$, $p>.05$, were significant and no significant interactions were found.

Accuracy: Incorrect Responses: The three-way mixed ANOVA conducted on participants' incorrect responses to neutral pictures and faces, showed that overall the BPT group made significantly more incorrect responses to the neutral faces and pictures by responding pleasant or unpleasant ($M = 16.06$) than the Control group ($M = 8.45$), $F(1,28) = 7.34$, $MSE = 236.47$, $p<.05$. No significant differences were found for Stimulus, $F(1,28) = 2.01$, $MSE = 188.979$, $p>.05$, or Task, $F(1,28) = 2.21$, $MSE = 40.43$, $p>.05$.

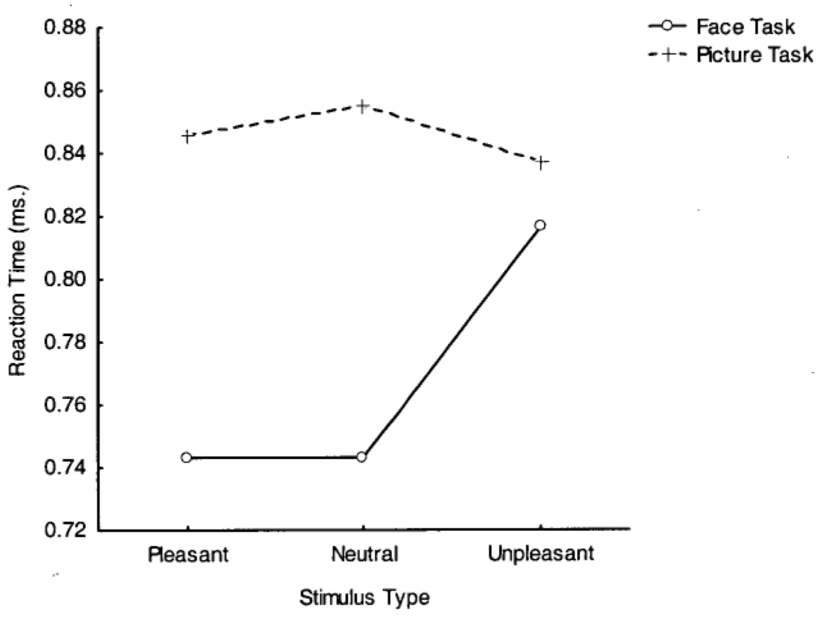

Figure 1. Mean reaction time when responding correctly to pleasant, neutral, and unpleasant faces and pictures for both the BPT and Control groups.

A significant two-way interaction was found between Task and Stimulus, $F(1,28) = 35.56$, $MSE = 2077.39$, $p<.001$, which was modified by a strong trend towards a significant three-way interaction between Group, Task and Stimulus, $F(1,28) = 3.75$, $MSE = 58.42$, $p=.06$ (see Figure 2). Breakdown ANOVAs by task indicated that, in addition to the BPT making more incorrect responses overall to both tasks, for the face task there was a significant main effect of Stimulus, $F(1,28) = 14.84$, $MSE = 174.21$, $p<.001$. Both groups were found to make significantly more incorrect unpleasant responses to the neutral faces ($M = 17.33\%$), than pleasant responses ($M = 5.45\%$; $p<.001$). In contrast, for the picture task a trend towards a significant main effect for Stimulus was found, $F(1,28) = 3.25$, $MSE = 104.74$, $p=.08$, with both the Control and BPT groups responding incorrectly to the neutral pictures more often with pleasant responses ($M = 15.50\%$), than unpleasant ($M = 10.74\%$; $p<.05$).

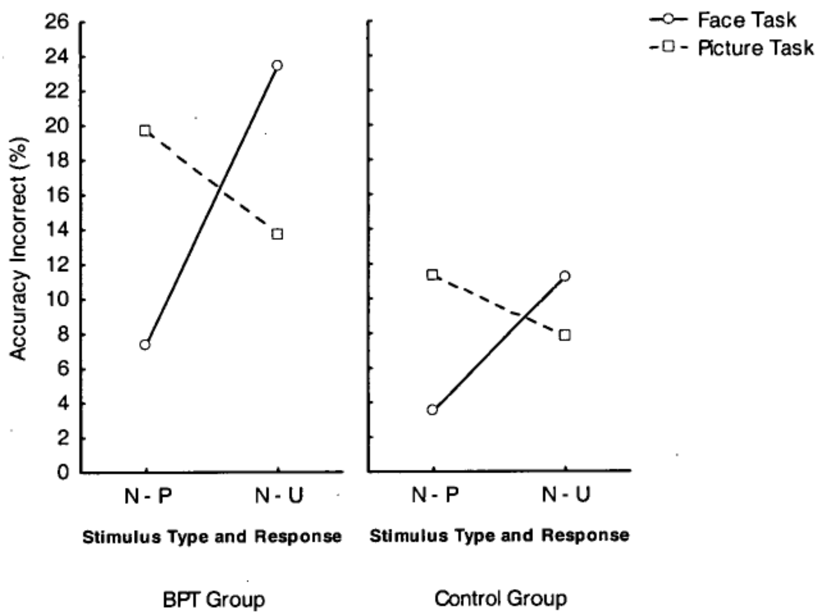

Figure 2. Mean percentage of incorrect pleasant and unpleasant responses to neutral faces and pictures for the BPT and Control groups.

Summary: In summary, the accuracy results show that both groups of participants were more able to identify pleasant and unpleasant stimuli correctly than neutral stimuli, in both the face and picture tasks. When making incorrect responses to neutral stimuli, the BPT group were found to make significantly more incorrect responses overall (by responding both pleasant and unpleasant) than the control group, and both groups of participants were shown to make more unpleasant responses to the neutral faces and pleasant responses to the neutral pictures.

ERP Data

Grand mean averages for correct responses to the three Stimulus types (unpleasant [average trials = 23], neutral [average trials = 80], and pleasant [average trials = 24]) and incorrect pleasant (average trials = 14) and unpleasant (average trials = 19) responses to the neutral stimuli were calculated for each task (picture and face) for both groups (BPT and Control) for the 15 electrode sites. This data is presented in Figures 3 (correct responses to faces); 4 (incorrect unpleasant and pleasant responses to neutral faces); 5 (correct responses to pictures); and 6 (incorrect unpleasant and pleasant responses to neutral pictures).

As can be seen in Figures 3 (a: unpleasant faces; b: neutral faces; and c: pleasant faces) when making correct responses to the faces, LPC amplitude was larger over central and parietal sites, decreasing in amplitude towards frontal sites, and was larger over the midline and right hemisphere sites than the left hemisphere sites, with the lowest amplitudes observed over far left and far right coronal sites. LPC was larger in response to pleasant and unpleasant faces, than neutral faces, over all sites, and was generally larger for the Control group than the BPT group.

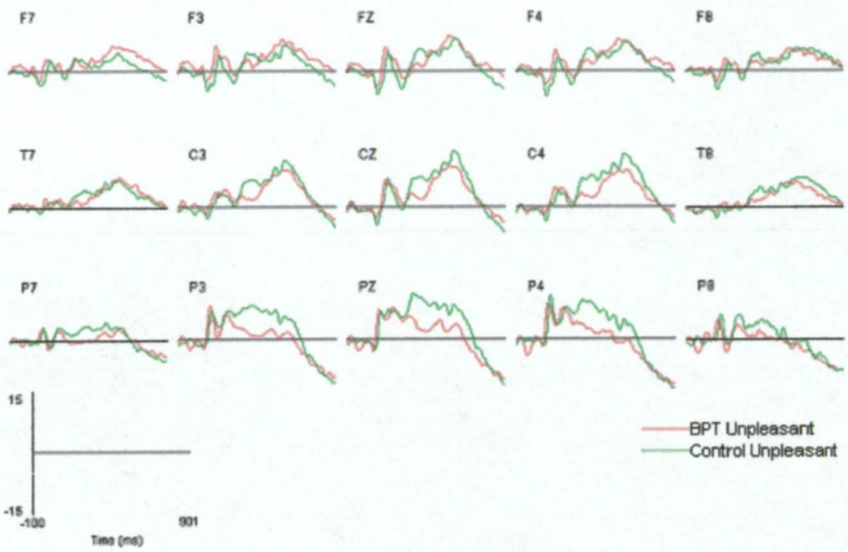

Figure 3a. ERP grand means for correct responses to unpleasant faces for the BPT and Control groups.

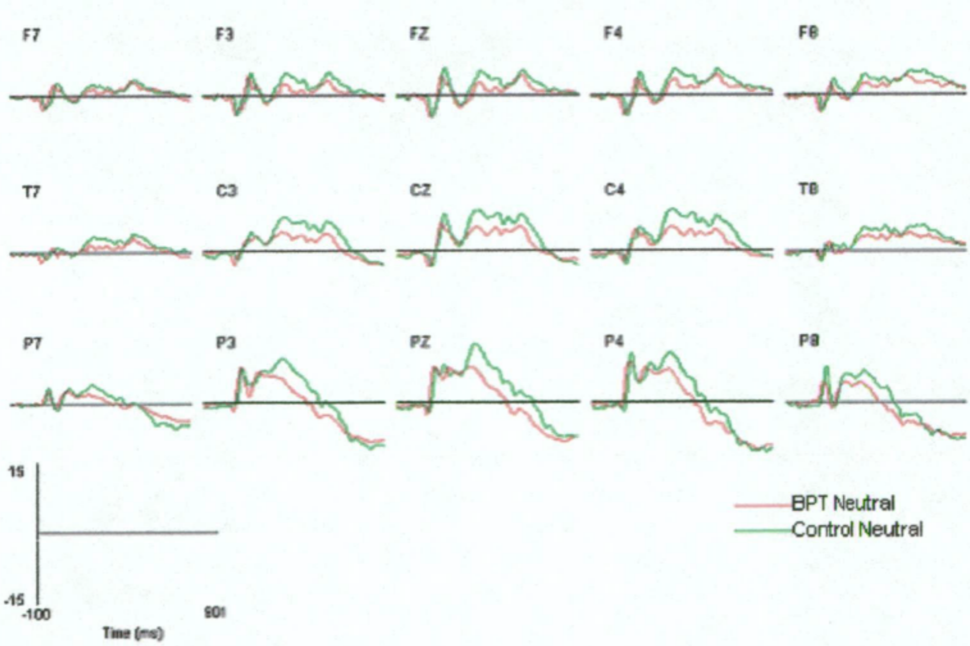

Figure 3b. ERP grand means for correct responses to neutral faces for the BPT and Control groups.

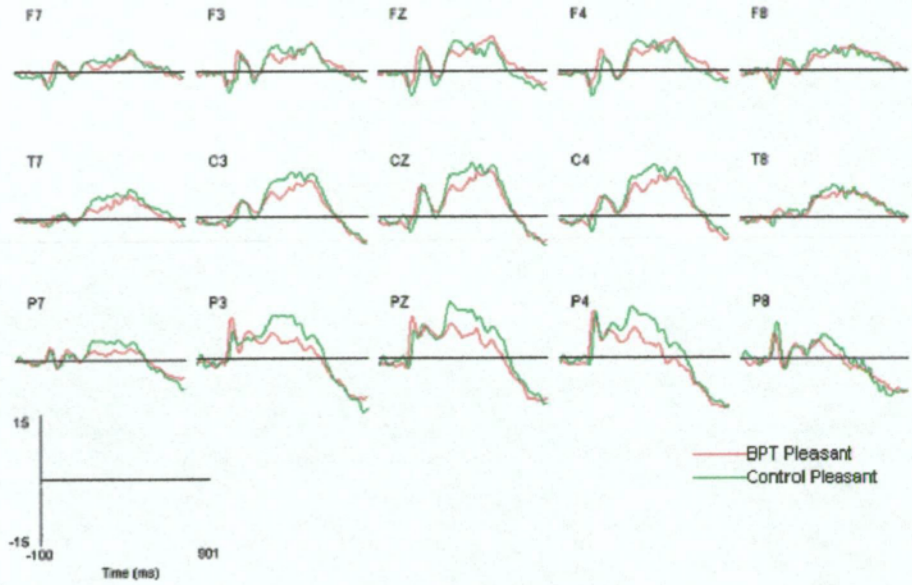

Figure 3c. ERP grand means for correct responses to pleasant faces for the BPT and Control groups.

P300 amplitude was larger across parietal and central sites than frontal sites, and larger over left, midline, and right coronal sites, than the far left and far right coronal sites. P300 amplitude did not generally vary as a function of Stimulus or Group.

Grand mean averages for incorrect pleasant and unpleasant responses to neutral faces can be seen in Figure 4 (a: pleasant responses to neutral faces and b: unpleasant responses to neutral faces). LPC amplitude was greater across the central and parietal sites, than the frontal sites, and was larger over the left, midline and right sites, than the far-left and far-right coronal sites. In general, the control group had greater LPC amplitude over the left, midline and right, frontal, central and parietal sites than the BPT group.

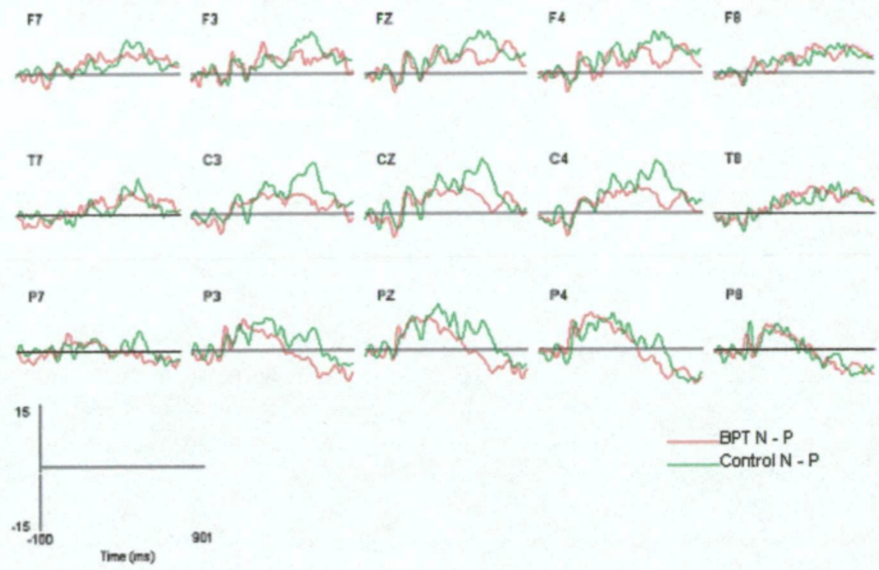

Figure 4a. ERP grand means for incorrect pleasant responses to neutral faces (N-P) for the BPT and Control groups.

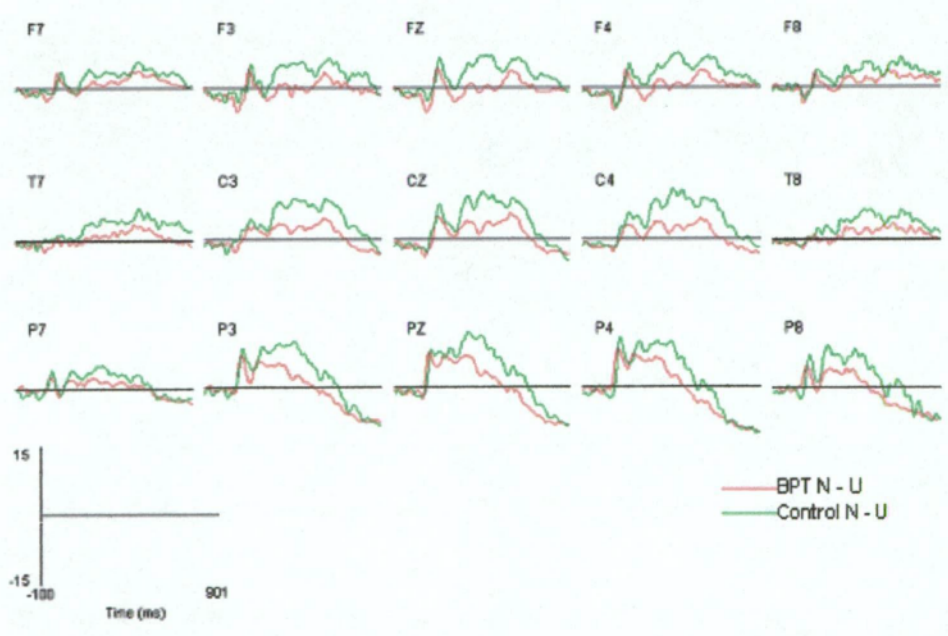

Figure 4b. ERP grand means for incorrect unpleasant responses to neutral faces (N-U) for the BPT and Control groups.

P300 amplitude was larger across parietal sites than frontal and central sites, and larger over left, midline, right and, far right coronal sites, than the far left sites. P300 amplitude was generally larger for unpleasant responses to neutral faces, than pleasant responses, but little differences in amplitude were observed between the groups.

As can be seen in Figure 5 (a: unpleasant pictures; b: neutral pictures; c: pleasant pictures), LPC amplitude was larger over the central and parietal sites, decreasing in amplitude over the frontal sites, and was larger over the left, midline and right sites, with the lowest amplitude observed over the far-left sites coronal sites. LPC was greater in response to pleasant and unpleasant pictures, than neutral pictures, and the BPT group showed lower amplitude across the central and parietal sites, but not across the frontal sites.

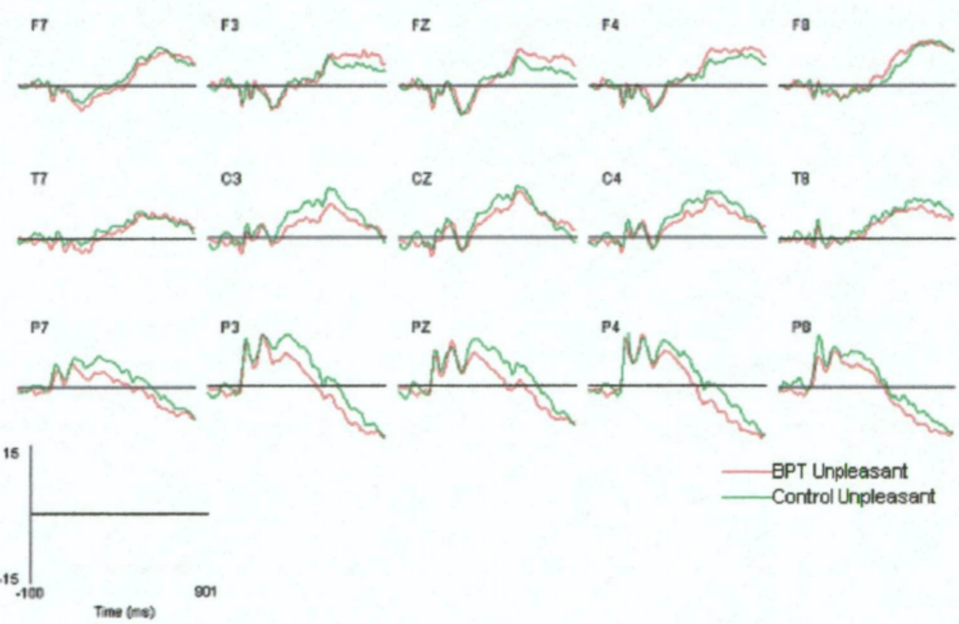

Figure 5a. ERP grand means for correct responses to unpleasant pictures for the BPT and Control groups.

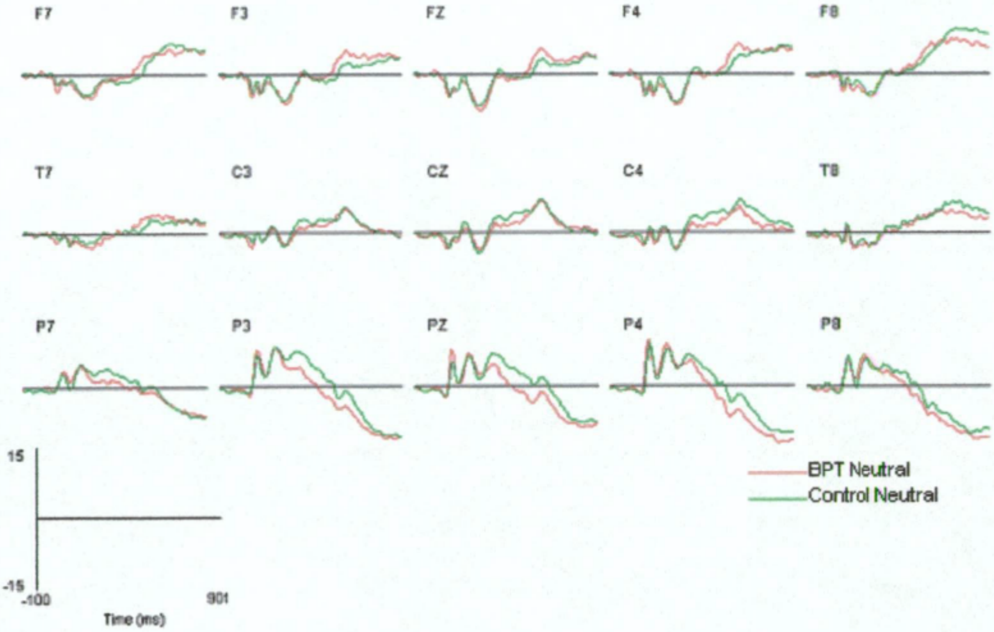

Figure 5b. ERP grand means for correct responses to neutral pictures for the BPT and Control groups.

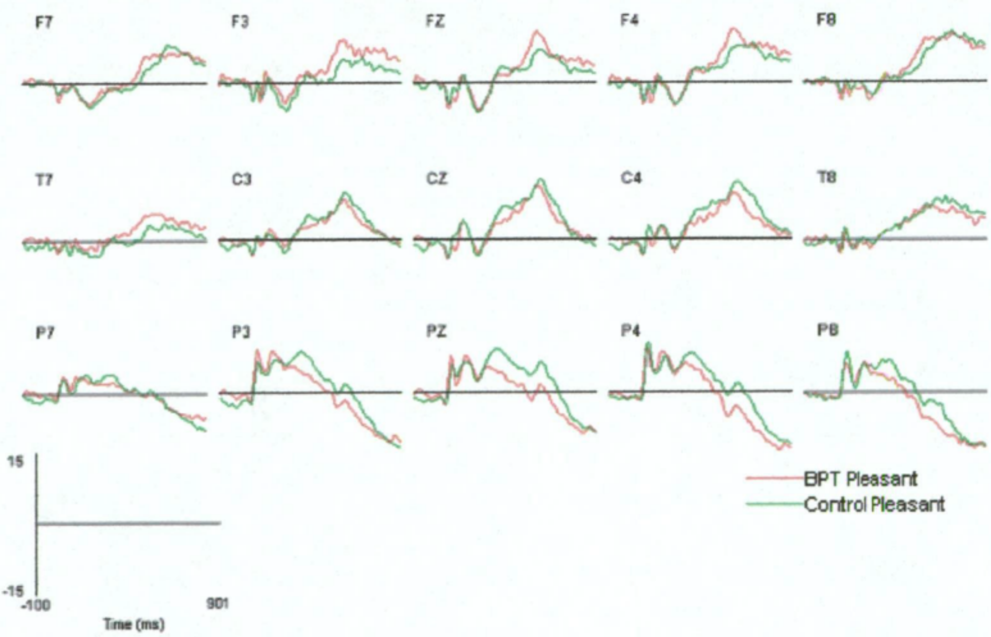

Figure 5c. ERP grand means for correct responses to pleasant pictures for the BPT and Control groups.

P300 amplitude was larger across parietal sites than frontal and central sites, and was larger across left, midline, right, and far right coronal sites, than far left sites. Larger P300 amplitude was shown for the pleasant and unpleasant pictures than for the neutral pictures, but in general there was little difference between the groups.

For incorrect pleasant and unpleasant responses to the neutral pictures, as can be seen in Figure 6 (a: pleasant responses to neutral pictures and b: unpleasant responses to neutral pictures), LPC amplitude was larger over the central and parietal sites, than the frontal sites, being greatest in the left, midline, and right sites, and lowest in the far-left and far-right coronal sites. LPC was larger when participants responded pleasant to the neutral pictures, and lower in general when they responded unpleasant. The Control group had larger LPC amplitude in general across all sites than the BPT group but especially over the central and parietal sites.

P300 amplitude was larger across parietal sites than frontal and central sites, and larger over left, midline, right, and far right coronal sites than far left sites. Larger amplitude was shown for unpleasant responses to the neutral stimuli, than for pleasant responses, but in general group differences were small.

The ERP pattern of response shown for pictures, whether making incorrect or correct responses, was similar to that shown by participants when attending to the face stimuli, suggesting that participants used similar attentional resources when responding to stimuli in both the face and picture tasks.

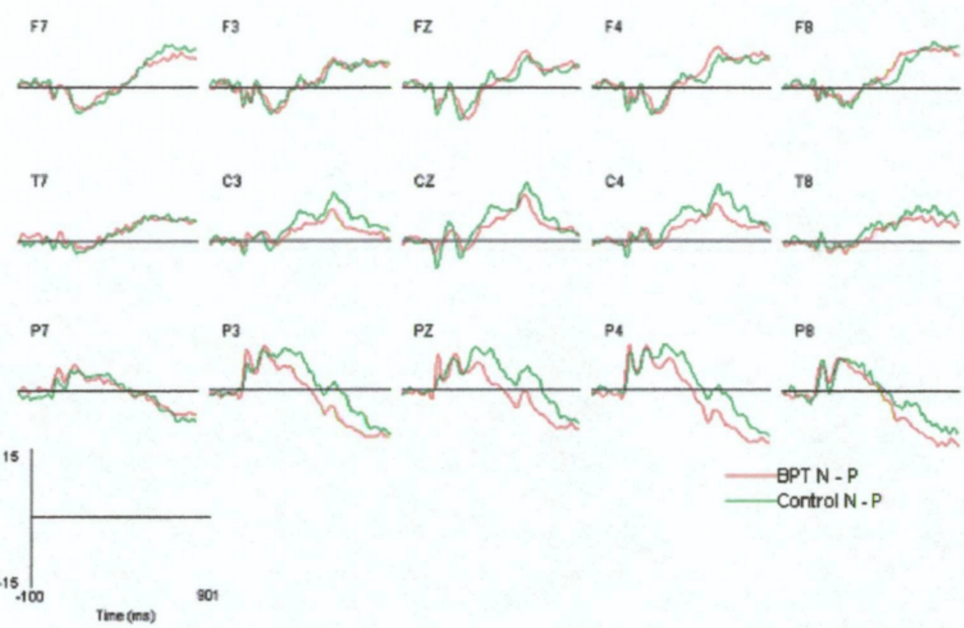

Figure 6a. ERP grand means for incorrect pleasant responses to neutral pictures (N-P) for the BPT and Control groups.

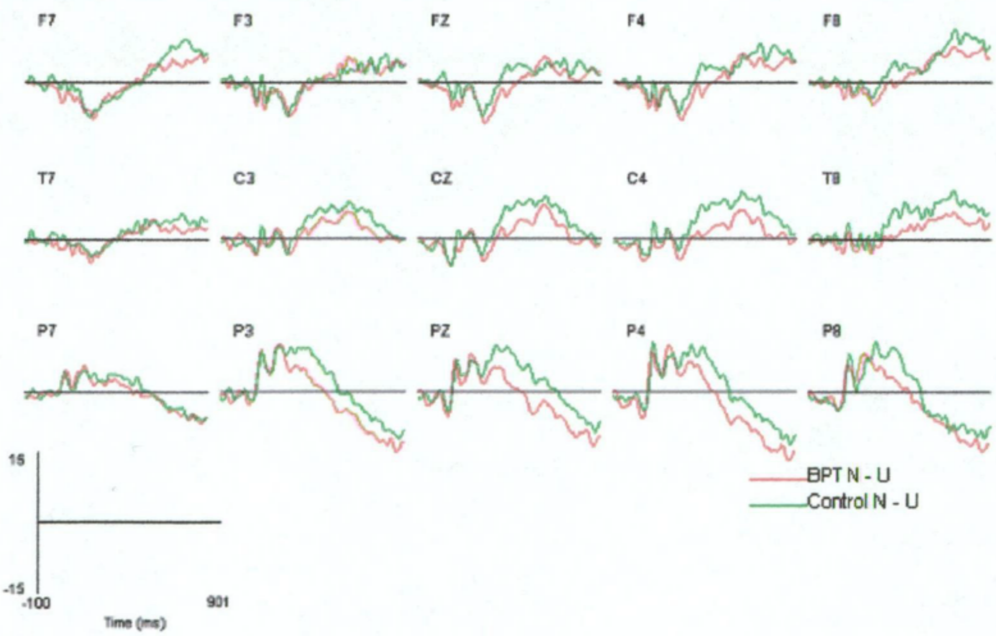

Figure 6b. ERP grand means for incorrect unpleasant responses to neutral pictures (N-U) for the BPT and Control groups.

Correct Responses

P300 Amplitude: The five-way mixed ANOVA conducted on the P300 amplitude data for correct responses to stimuli in both tasks showed a significant main effect for Stimulus, $F(2,56) = 12.89$, $MSE = 49.19$, $p<.001$. Pairwise comparisons demonstrated that P300 amplitude was significantly greater for both groups on both tasks for the unpleasant ($M = 7.67\mu V$) and pleasant ($M = 7.62\mu V$) faces and pictures, than for the neutral faces and pictures ($M = 6.27\mu V$; $p<.001$). A significant main effect was found for Task, $F(1,28) = 17.02$, $MSE = 131.14$, $p<.001$. Participants responded with larger P300 amplitude when making correct responses to faces ($M = 8.10\mu V$) than to pictures ($M = 6.28\mu V$). Significant main effects were also found for Sagittal, $F(2,56) = 42.90$, $MSE = 252.29$, $p<.001$, and Coronal sites, $F(4,112) = 57.95$, $MSE = 67.31$, $p<.001$, however no significant differences in P300 amplitude were found for Group, $F(1,28) = 0.94$, $MSE = 584.33$, $p>.05$.

The main effects of Stimulus, Task, Sagittal, and Coronal sites were modified by significant two and three-way interactions. Significant two-way interactions were found between Task and Stimulus, $F(2,56) = 4.06$, $MSE = 37.97$, $p<.03$, Task and Sagittal sites, $F(2,56) = 40.24$, $MSE = 21.13$, $p <.001$, and Task and Coronal sites, $F(4,112) = 8.86$, $MSE = 10.00$, $p<.001$. Significant two-way interactions were also found between Stimulus and Sagittal sites, $F(4,112) = 3.57$, $MSE = 21.13$, $p<.05$, Stimulus and Coronal sites, $F(8,224) = 4.32$, $MSE = 8.97$, $p=.002$, and Sagittal and Coronal sites, $F(8,224) = 5.45$, $MSE = 27.93$, $p<.001$. These significant two-way interactions were modified by significant three-way interactions.

A significant three-way interaction (see Figure 7) was found between Task, Stimulus and Sagittal sites, $F(4,112) = 4.54$, $MSE = 20.28$, $p<.02$. For the face task, breakdown ANOVAs indicated a trend towards an interaction between Stimulus and Sagittal sites, $F(4,112) = 2.96$, $MSE = 27.83$, $p=.06$. Pairwise comparisons showed that P300 amplitude was significantly greater for pleasant faces in central (M = 8.91μV.) and frontal sites (M =7.49μV) than for unpleasant (frontal M = 6.84μV; central M = 7.84μV.) and neutral (frontal M = 5.48μV; central M = 6.94μV.) faces (p<.001). No significant differences were found across parietal sites.

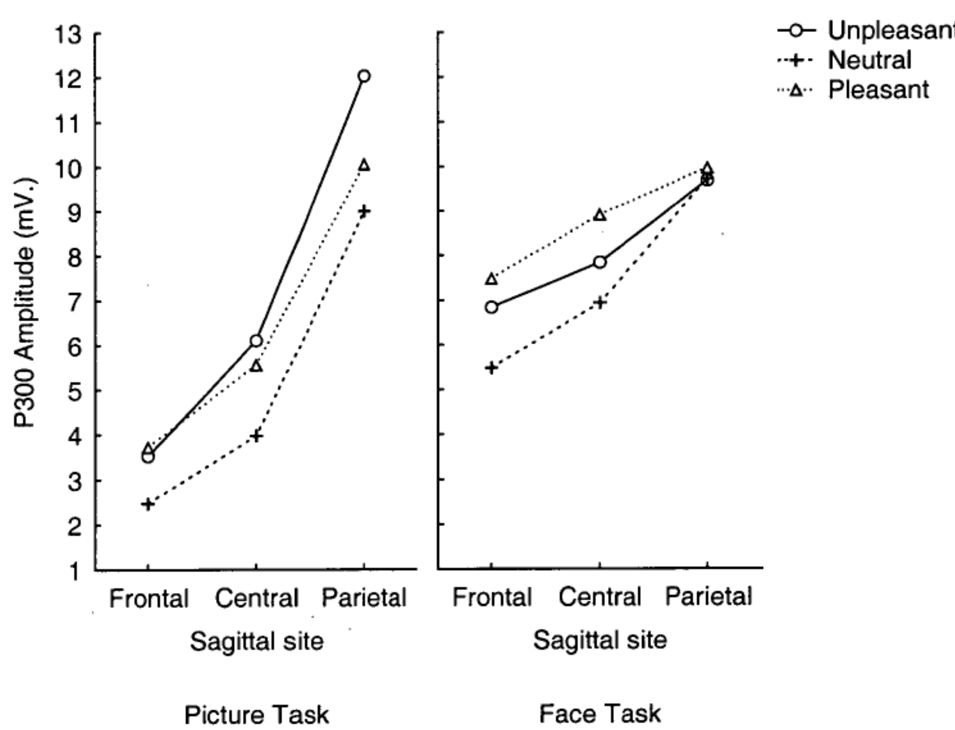

Figure 7. P300 amplitude for correct responses to pleasant, neutral, and unpleasant faces and pictures.

In contrast, for the picture task, breakdown ANOVAs revealed a significant interaction between Stimulus and Sagittal sites, $F(4,112) = 5.56$, $MSE = 15.99$, $p<.01$. Pairwise comparisons showed that P300 amplitude was significantly greater for unpleasant pictures across parietal ($M = 12.03\mu$V.) and central sites ($M = 6.11\mu$V.), than for pleasant (parietal $M = 10.07\mu$V; central $M = 5.57\mu$V.) and neutral (parietal $M = 8.99\mu$V; central $M = 3.98\mu$V.) pictures. For the frontal sites, P300 amplitude was found to be significantly greater to unpleasant ($M = 3.57\mu$V.) and pleasant pictures ($M = 3.73\mu$V.) than to neutral pictures ($M = 2.48\mu$V.).

A significant three-way interaction was also found between Task, Sagittal and Coronal sites, $F(8,224) = 3.44$, $MSE = 10.95$, $p<.02$. Breakdown ANOVAs showed that for the face task, there was a significant interaction between Sagittal and Coronal sites, $F(8,224) = 7.57$, $MSE = 14.25$, $p<.001$, with significant differences in P300 amplitude occurring mainly in the central and parietal sites, in the right and far right Coronal sites. For the picture task, a significant interaction was also found between Sagittal and Coronal sites, $F(8,224) = 3.05$, $MSE = 22.99$, $p<.02$, with significant differences in P300 amplitude occurring across all Sagittal sites mainly in the left and midline Coronal sites but not in the right and far right sites.

P300 Latency: The five-way mixed ANOVA conducted on P300 latency data for participants' correct responses to stimuli in both tasks showed a trend towards a significant main effect for Group, $F(1,28) = 3.45$, $MSE = 136728.22$, $p=.07$. The BPT group exhibited shorter P300 latency ($M = 289.98$ms.) to both faces and pictures, than the Control group ($M = 316.40$ms.). A significant main effect was also found for Stimulus, $F(2,56) = 4.37$, $MSE = 6498.07$, $p<.02$, with pairwise comparisons revealing that participants responded with a longer P300 latency to pleasant faces and pictures (M = 309.46ms.), than to unpleasant faces and pictures (M = 298.82ms.). A significant main effect was found for Sagittal sites, $F(2,56) = 15.25$, MSE = 44987.56, $p<.001$, however, no significant differences were found in latency as a function of Coronal sites, $F(4,112) = 0.87$, MSE = 14494.22, $p>.05$.

These significant main effects were modified by significant two-way interactions between Stimulus and Sagittal sites, $F(4,112) = 2.83$, MSE = 3233.61, $p<.05$, and between Stimulus and Group, $F(2,56) = 3.37$, MSE = 6498.07, $p<.05$. As can be seen in Figure 8 below, the BPT group exhibited shorter P300 latency overall than the Control group, with P300 latency being significantly longer for the pleasant (M = 297.28ms.) than the unpleasant faces and pictures (M = 280.30ms; $p<.001$). In contrast, the Control group exhibited significantly longer P300 latency to pleasant (M = 321.63ms.) and unpleasant (M = 317.40ms.) faces and pictures, than to neutral faces and pictures (M = 310.22ms; $p<.001$), with no significant differences being found between responses to pleasant and unpleasant stimuli. In addition, P300 latency was found to be significantly longer overall for the Control group, than for the BPT group.

These effects were further modified by a significant three-way interaction between Group, Stimulus, and Coronal sites, $F(8,224) = 2.41$, MSE = 3666.47, $p<.05$, as can be seen in Figure 9. Breakdown ANOVAs indicated for the BPT group a significant interaction between Stimulus and Coronal sites, $F(8,112) = 2.93$, MSE = 5005.63, $p<.01$, and P300 latency was found to be longest overall for the pleasant stimuli. In contrast, a significant interaction was not found between Stimulus and

Coronal sites for the Control group, $F(8,112) = 0.96$, $MSE = 3360.76$, $p<.05$, however, a longer P300 latency for pleasant, than neutral and unpleasant faces and pictures can be seen. The interaction with coronal site appears to be being caused by larger right hemisphere differences across the stimuli for the BPT group and while not significant, larger left hemisphere differences across stimulus types for the control group.

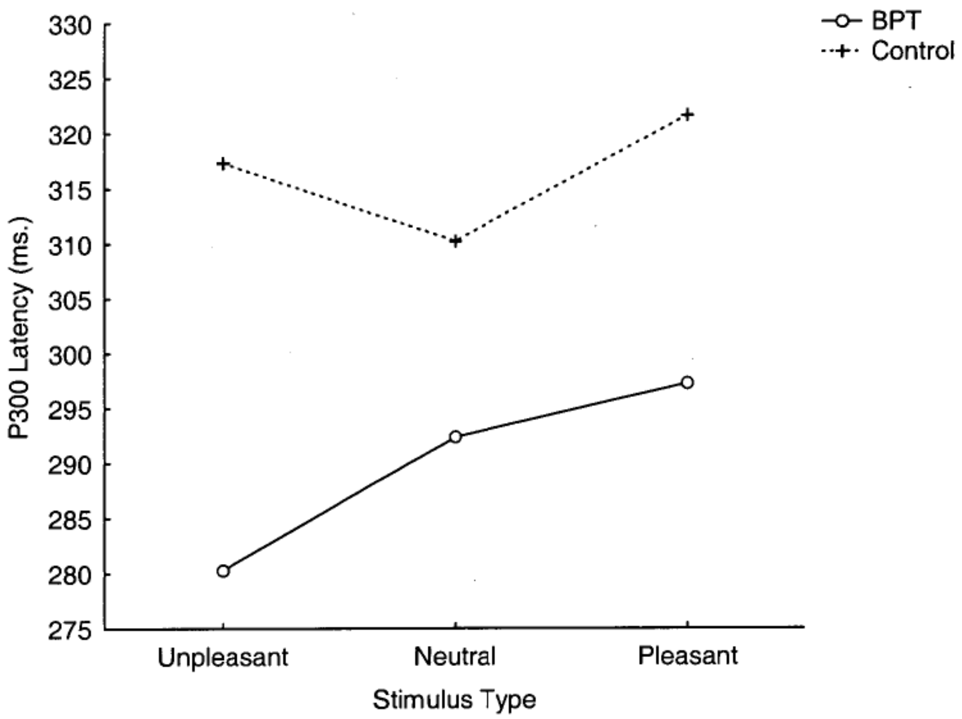

Figure 8. P300 latency for correct responses to pleasant, neutral, and unpleasant faces and pictures for the BPT and Control groups.

A trend towards a significant three-way interaction between Group, Task and Sagittal sites can be seen in Figure 10, $F(2,56) = 2.81$, $MSE = 5354.69$, $p=.08$. Breakdown ANOVAs indicated that for the BPT group, there was a significant two-way interaction between Task and Sagittal sites, $F(2,28) = 3.62$, $MSE = 7204.59$, $p<.05$, with no significant differences in P300 latency found across Sagittal sites for the faces, but significantly longer latency to the pictures in the frontal and central Sagittal sites than the parietal. In contrast, a significant interaction was not found between Task and Sagittal sites for the Control group, and P300 latency was found to be significantly longer in the frontal and central Sagittal sites than the parietal sites for both the pictures and faces.

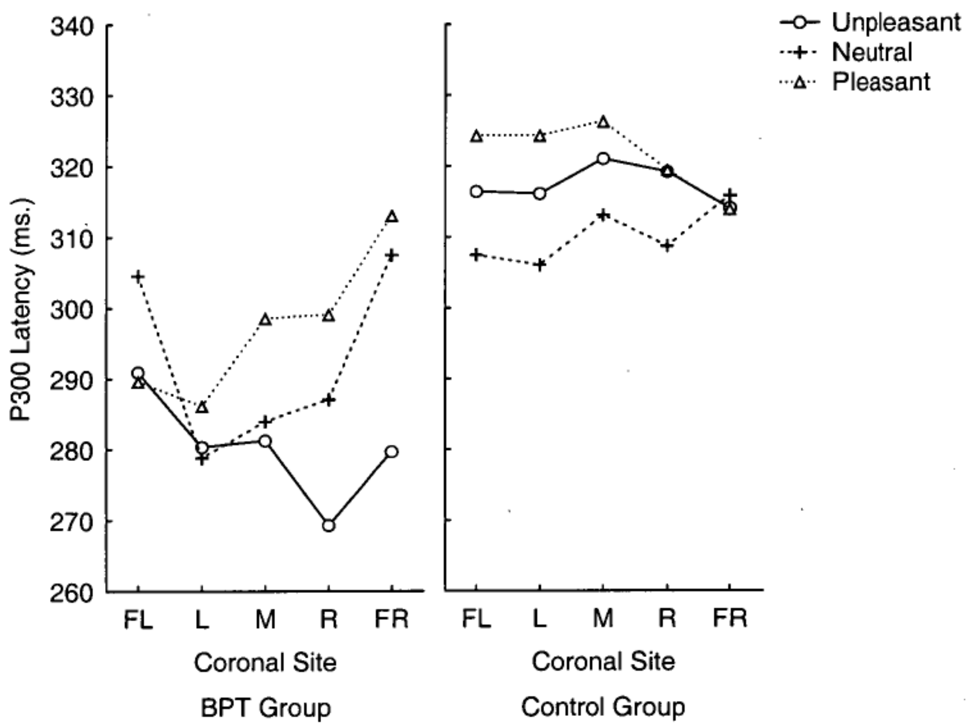

Figure 9. P300 latency for correct responses to pleasant, neutral, and unpleasant faces and pictures across Coronal sites (far-left, left, midline, right, far-right) for the BPT and Control groups.

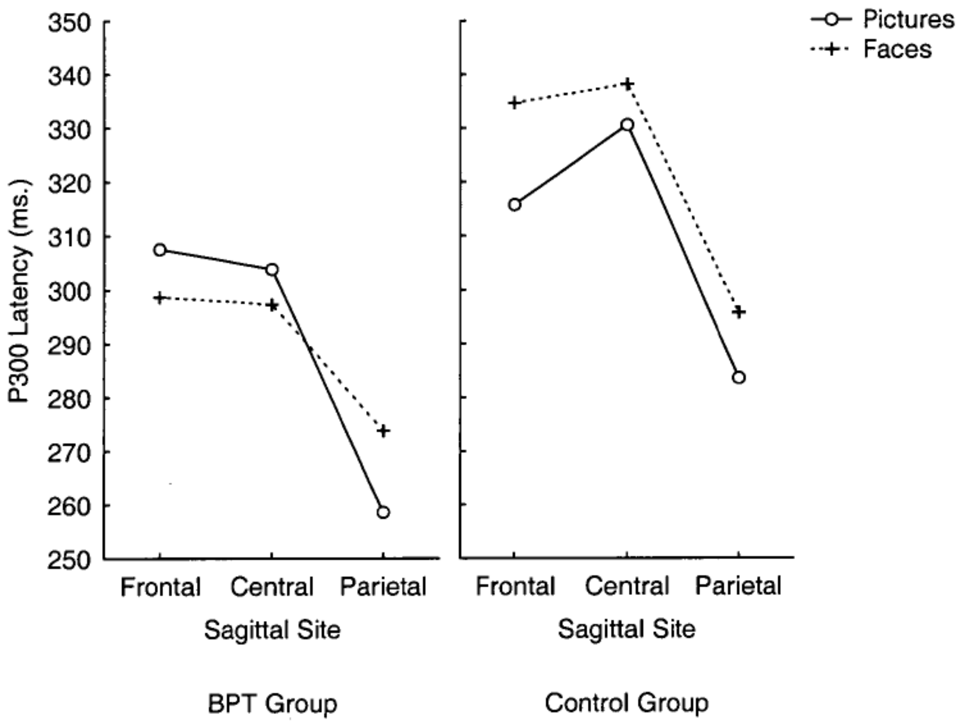

Figure 10. P300 latency for correct responses to faces and pictures across Sagittal sites (frontal, central, parietal) for the BPT and Control groups.

LPC Amplitude: The five-way mixed ANOVA conducted on the LPC amplitude data for correct responses to both tasks indicated a significant main effect of Stimulus, $F(2,56) = 65.37$, $MSE = 57.42$, $p<.001$. Pairwise comparisons showed that participants responded with greater LPC amplitude in both tasks, when making correct responses to unpleasant ($M = 9.39\mu V$) and pleasant faces and pictures ($M = 9.32\mu V$) than to neutral faces and pictures ($M = 5.92\mu V$). Significant main effects were also found for Sagittal, $F(2,56) = 21.32$, $MSE = 247.66$, $p<.001$, and Coronal sites, $F(4,112) = 23.53$, $MSE = 67.83$, $p<.001$. Significant main effects were not found for Group, $F(1,28) = 2.57$, $MSE = 511.13$, $p>.05$, or Task, $F(1,28) = 0.18$, $MSE = 99.88$, $p>.05$.

Significant two-way interactions were found between Task and Sagittal sites, $F(2,56) = 9.99$, $MSE = 43.83$, $p<.001$, Task and Coronal sites, $F(4, 112) = 5.95$, $MSE = 36.64$, $p<.01$, Stimulus and Sagittal sites, $F(4,112) = 4.79$, $MSE = 15.84$, $p<.01$, Stimulus and Coronal sites, $F(8,224) = 12.33$, $MSE = 8.92$, $p<.001$, and Sagittal and Coronal sites, $F(8,224) = 5.59$, $MSE = 67.60$, $p<.001$.

As can be seen in Figure 11, a significant two-way interaction was also found between Sagittal sites and Group, $F(2,56) = 5.78$, $MSE = 247.66$, $p<.05$. Breakdown analyses showed that for the BPT group there was a significant main effect of Sagittal sites, $F(2,28) = 26.13$, $MSE = 210.93$, $p<.001$, with LPC amplitude being significantly greater in frontal ($M = 9.05\mu V.$) and central ($M = 9.19\mu V.$) sites when participants were responding correctly to faces and pictures, than in parietal sites ($M = 4.31\mu V.$). For the Control group, a significant main effect was found for Sagittal sites, $F(2,28) = 4.44$, $MSE = 314.14$, $p<.05$, with LPC amplitude shown, in contrast, to be significantly greater in central sites ($M = 10.41\mu V.$), than in parietal sites ($M = 7.80\mu V$; $p<.001$). Both groups were found to respond similarly across the frontal sites, but a larger group difference can be seen across parietal sites, where the Control group responded with significantly greater LPC amplitude than the BPT group ($p<.001$)

These effects were further modified by a significant three-way interaction between Task, Stimulus and Sagittal sites, $F(4,112) = 7.83$, $MSE = 17.56$, $p<.001$ and a strong trend for a significant four-way interaction was found between Task, Stimulus, Coronal sites and Group, $F(8,224) = 13.95$, $MSE = 13.95$, $p=.05$, as can be seen in Figures 12 (controls) and 13 (BPT group) below. For the BPT group, amplitude was greater overall for the pleasant and unpleasant stimuli, than for the neutral stimuli, with a greater difference in response for the faces than for the pictures. Coronal activity was generally greater across the left, midline and right sites and was greater for the pleasant and unpleasant stimuli than the neutral. The control group showed a similar pattern of results, however larger amplitude was found for pictures and faces than the BPT group.

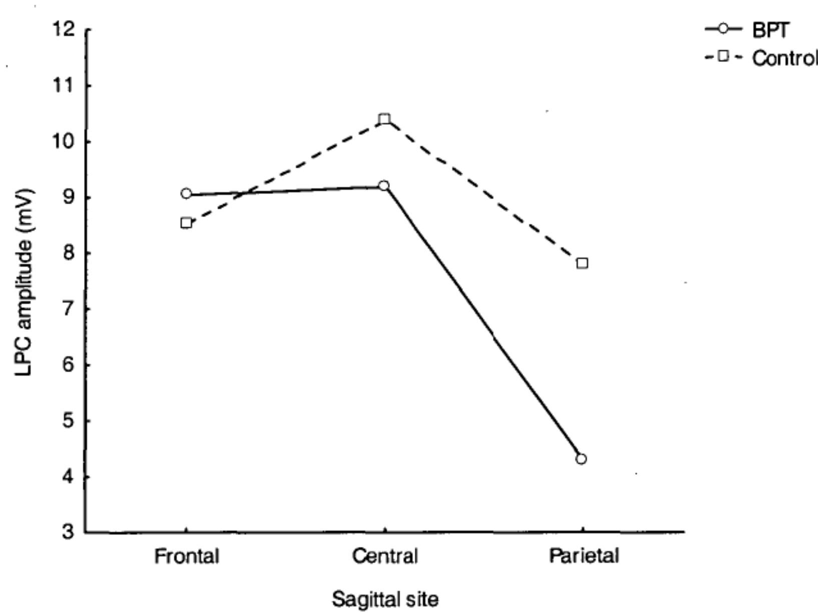

Figure 11. LPC amplitude for correct responses to faces and pictures across Sagittal sites (frontal, central, parietal) for the BPT and Control groups.

LPC Latency: The five-way mixed ANOVA conducted on the LPC latency data for correct responses to stimuli in both tasks showed that LPC latency was significantly longer when participants were correctly responding to pictures (*M* = 558.97ms.) than when they were responding correctly to faces (*M* = 533.31ms.), $F(1,28) = 26.81$, $MSE = 16585.25$, $p<.001$. A significant main effect was also found for Stimulus, $F(2,56) = 12.31$, $MSE = 8963.93$, $p<.001$. Pairwise comparisons showed that participants responded with significantly longer LPC latency when making correct responses to pleasant faces and pictures (*M* = 558.49 ms.), than when responding correctly to neutral (*M* = 539.58ms.) and unpleasant faces and pictures (*M* = 540.38ms.). Significant main effects were also found for Sagittal, $F(2,56) = 128.91$, $MSE = 31896.25$, $p<.001$, and Coronal sites, $F(4,112) = 9.77$, $MSE = 17462.09$, $p<.001$. The main effect of Group was not significant, $F(1,28) = 0.08$, $MSE = 125923.31$, $p>.05$.

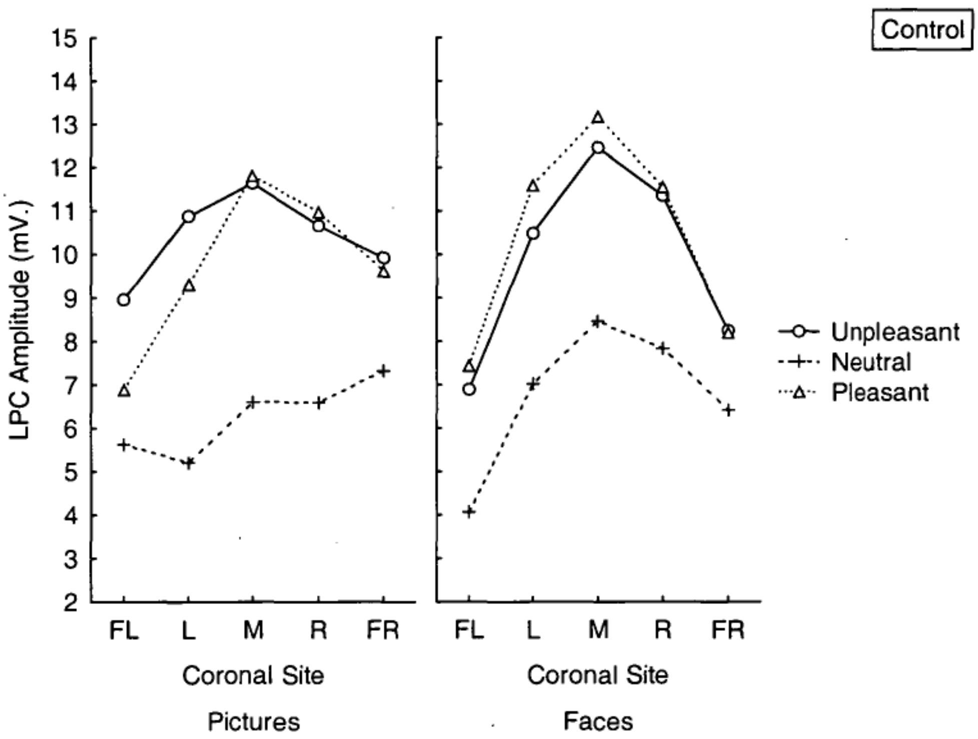

Figure 12. LPC amplitude for correct responses to unpleasant, neutral, and pleasant faces and pictures across far left (FL), left (L), midline (M), right (R), and far right (FR) coronal sites for the control group.

Significant two-way interactions were found between Task and Stimulus, $F(2,56) = 10.11$, $MSE = 12056.73$, $p<.001$, Task and Sagittal sites, $F(2,56) = 51.54$, $MSE = 6959.31$, $p<.001$, Stimulus and Sagittal sites, $F(4,112) = 7.01$, $MSE =$ 9232.40, <.001, and Sagittal and Coronal sites, $F(8,224) = 9.99$, $MSE = 10256.59$, $p<.001$. As can be seen below in Figure 14, a strong trend towards a significant interaction was found between Task and Group, $F(1,28) = 4.09$, $MSE = 16585.25$, $p=.05$. Breakdown ANOVAs indicated that for the BPT group there was a significant main effect of Task, $F(1,14) = 7.66$, $MSE = 10767.58$, $p=.02$, with participants responding with a significantly longer LPC latency when making correct responses to pictures (M = 555.93ms.), than to faces (M = 540.30ms.). For the Control group, a main effect of Task was also shown, $F(1,14) = 19.19$, $MSE = 22402.91$, p=.001, with participants responding with longer LPC latency to pictures (M = 562.02 ms.), than to faces (M = 526.32 ms.), with the difference in response to faces and pictures being much greater in the Control group than the BPT group and the BPT group responding with longer latency to the faces than the control group.

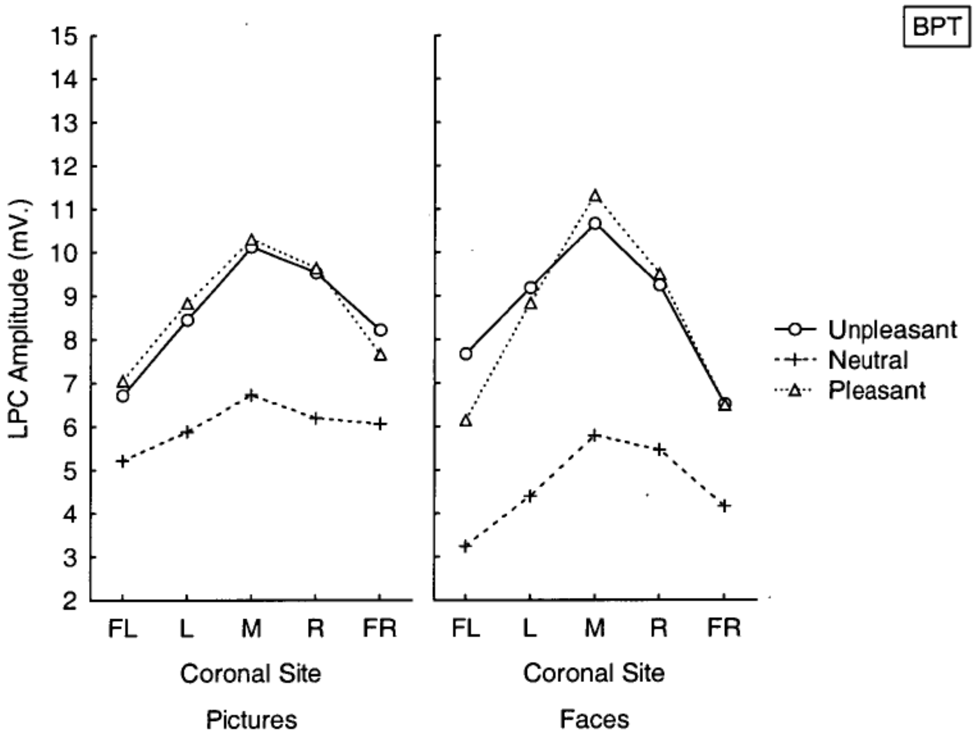

Figure 13. LPC amplitude for correct responses to unpleasant, neutral, and pleasant faces and pictures across far left (FL), left (L), midline (M), right (R), and far right (FR) coronal sites for the BPT group.

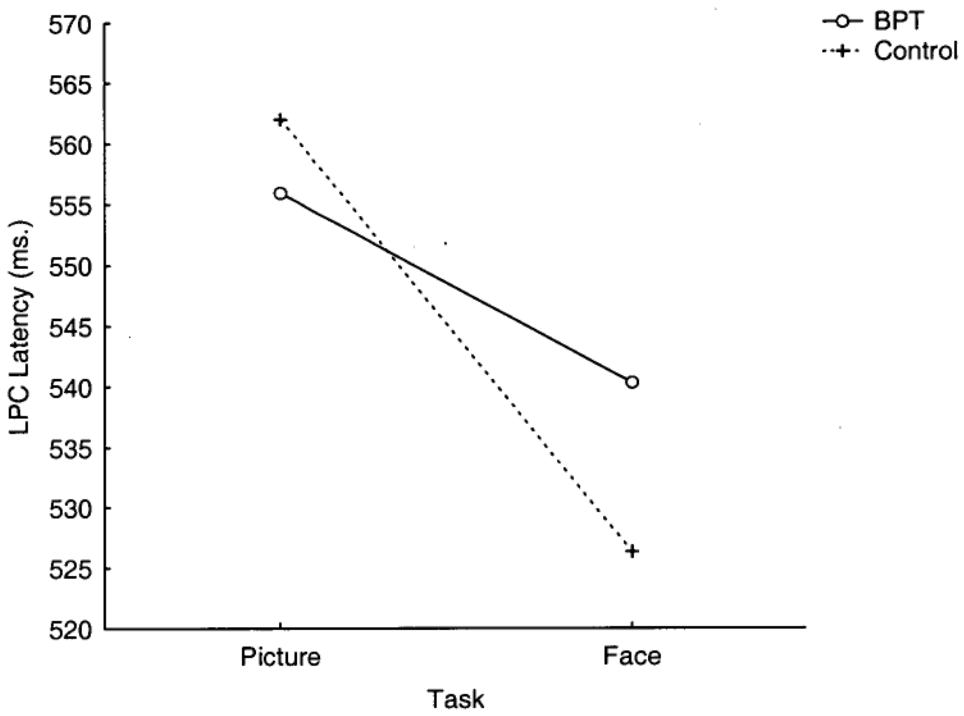

Figure 14. LPC latency for correct responses to faces and pictures for the BPT and Control groups.

A significant two-way interaction was found between Stimulus and Group, $F(2,56) = 3.56$, $MSE = 8963.93$, $p<.05$, as can be seen below in Figure 15. Breakdown ANOVAs indicated that the Control group responded with longer LPC latency when making correct responses to pleasant faces and pictures ($M = 563.02$ ms.), than when making correct responses to neutral ($M = 535.56$ ms.) and unpleasant faces and pictures ($M = 533.93$ ms.). No significant differences in response to the pleasant, unpleasant and neutral faces and pictures were found for the BPT group.

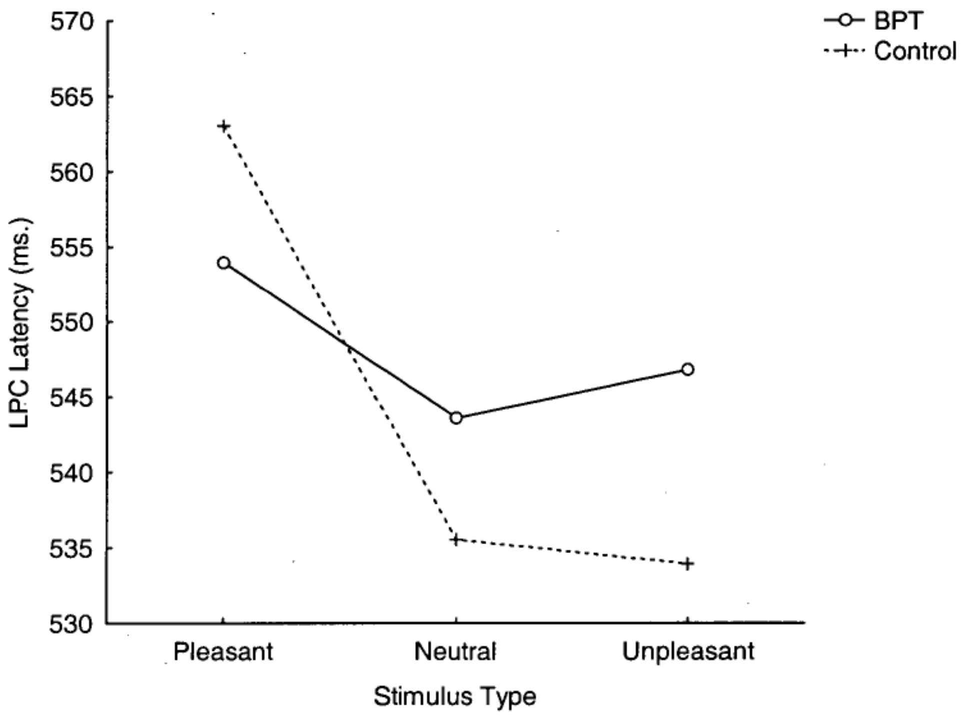

Figure 15. LPC latency for correct responses to pleasant, neutral, and unpleasant faces and pictures for the BPT and Control groups.

These effects were further modified by significant three-way interactions between Task, Sagittal and Coronal sites, $F(8{,}224) = 4.37$, $MSE = 3140.89$, $p<.001$, Task, Stimulus and Sagittal sites, $F(4{,}112) = 3.22$, $MSE = 6917.26$, $p<.05$, and Task, Stimulus and Coronal sites, $F(8{,}224) = 2.72$, $MSE = 3251.34$, $p<.02$. As can be seen below in Figure 16, a significant three-way interaction was also found between Task, Stimulus and Group, $F(2{,}56) = 3.40$, $MSE = 12056.73$, $p<.05$. Breakdown ANOVAs indicated a trend towards a significant effect of Stimulus for the BPT group's response to the faces, $F(2{,}28) = 3.17$, $MSE = 14892.82$, $p=.06$, but not for the pictures, with the BPT group responding with longer LPC latency when making correct responses to pleasant faces ($M = 553.80$ms.), than neutral ($M = 528.84$ms.) or unpleasant faces (M = 538.25ms.). In contrast, the Control group data showed a significant main effect of Stimulus for the faces but not for the pictures, F (2,28) = 16.91, MSE = 15034.07, p<.001, with participants responding with a significantly longer LPC latency when making correct responses to pleasant faces (M = 563.88ms.), than neutral (M = 514.57ms.) and unpleasant faces (M = 500.53ms.), and longer for neutral than unpleasant faces.

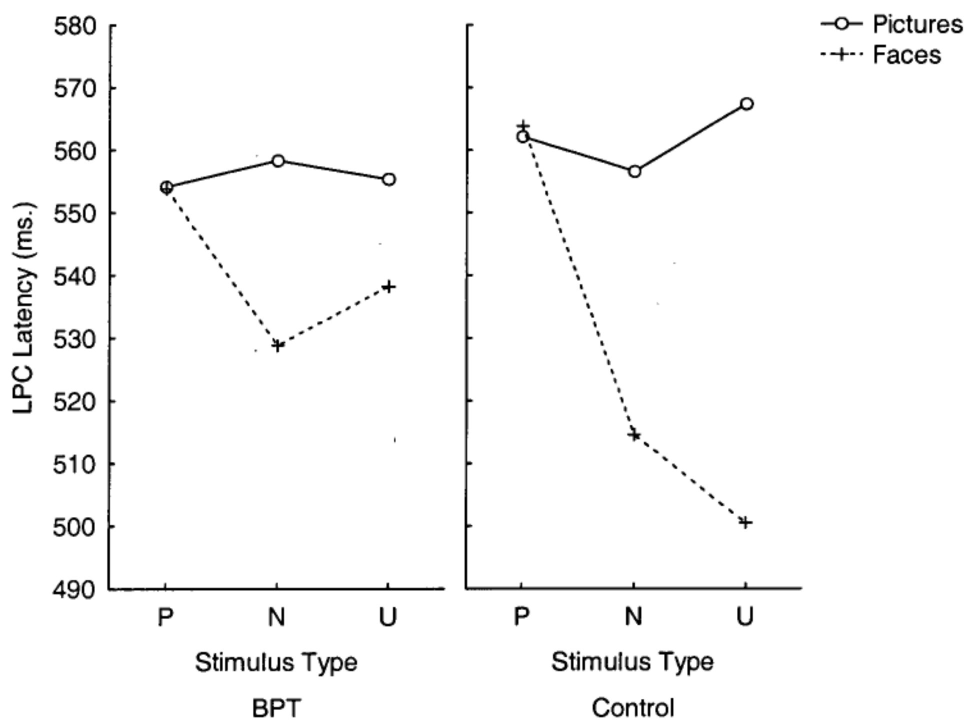

Figure 16. LPC latency for correct responses to pleasant, neutral, and unpleasant faces and pictures for the BPT and Control groups.

Incorrect Responses

P300 Amplitude: The five-way mixed ANOVA conducted on the P300 amplitude data for incorrect responses to the neutral stimuli in both tasks showed a trend towards a significant main effect of Group, $F(1,22) = 3.28$, $MSE = 1969.43$, $p=.08$. The Control group responded with higher P300 amplitude when making incorrect responses to neutral faces and pictures ($M = 8.32\mu$V.) than the BPT group ($M = 6.69\mu$V). A significant main effect was found for Task, with participants' responding with significantly greater P300 amplitude to faces ($M = 10.66\mu$V) than to pictures ($M = 6.77\mu$V), $F(1,22) = 17.55$, $MSE = 307.37$, $p<.001$. Significant main effects were also found for Sagittal, $F(2,44) = 29.40$, $MSE = 195.96$, $p<.001$ and Coronal sites, $F(4,88) = 30.79$, $MSE = 65.13$, $p<.001$, however a significant main effect was not found for Stimulus, $F(1,22) = 2.66$, $MSE = 321.31$, $p>.05$.

These significant main effects were modified by a significant two-way interaction between Task and Stimulus, $F(1,22) = 5.31$, $MSE = 230.10$, $p<.05$. Breakdown ANOVAs indicated that for the face task there was a strong trend for a significant main effect of Stimulus, $F(1,22) = 4.39$, $MSE = 469.45$, $p=.05$. Participants' responded with larger P300 amplitude when making pleasant responses to the neutral faces ($M = 12.35\mu$V.) than when making unpleasant responses ($M = 8.96\mu$V.). For the picture task, however, there was no main effect for Stimulus as participants responded with similar levels of P300 amplitude when making pleasant and unpleasant incorrect responses. Significant two-way interactions were also found between Task and Sagittal sites, $F(2,44) = 14.63$, $MSE = 69.35$, $p<.001$ and Task and Coronal sites, $F(4,88) = 3.20$, $MSE = 23.94$, $p<.05$. In general, amplitude was higher across all sites for the face task than the picture task and highest for both tasks in parietal sites and across left, midline, and right coronal sites.

P300 Latency: The five-way mixed ANOVA conducted on the P300 latency data for incorrect responses to neutral stimuli in both tasks showed that the BPT group responded with significantly shorter P300 latency (M = 285.49ms.) when making incorrect responses to the neutral faces and pictures, than the Control group (M = 320.58ms.), $F(1,22) = 4.68$, $MSE = 78744.84$, $p<.05$. A significant main effect was also found for Sagittal sites, $F(2,44) = 21.66$, $MSE = 18132.06$, $p<.001$, with latency being found to be significantly longer across frontal (M = 320.34ms.) and central (M = 316.78ms.) sites than parietal sites (M = 276.48ms; p<.001). Significant main effects were not found for Task, $F(1,22) = 0.04$, $MSE = 20874.82$, $p>.05$, Stimulus, $F(1,22) = 0.54$, $MSE = 5909.98$, $p>.05$, or Coronal sites, $F(4,88) = 0.23$, $MSE = 7157.29$, $p>.05$. These main effects were modified by a significant two-way interaction between Task and Sagittal sites, $F(2,44) = 4.01$, $MSE = 4578.13$, $p<.03$, with latency being longer across frontal, and central sites than parietal sites for both tasks, and generally larger overall in the picture task than the face task.

LPC Amplitude: The five-way mixed ANOVA conducted on the LPC amplitude data for incorrect responses to neutral stimuli in both tasks showed that the BPT group responded with significantly lower LPC amplitude (M = 7.68μV.) when making incorrect responses to neutral faces and pictures, than the Control group (M = 12.05μV.), $F(1,22) = 8.05$, $MSE = 845.54$, $p<.02$. Significant main effects were also found for Sagittal, $F(2,44) = 15.25$, $MSE = 192.32$, $p<.001$, and Coronal sites, $F(4,88) = 14.98$, $MSE = 74.66$, $p<.001$. Significant main effects were not found for Task, $F(1,22) = 2.99$, $MSE = 440.27$, $p<.05$, or Stimulus, $F(1,22) = 2.79$, $MSE = 710.95$, $p>.05$.

Significant two-way interactions were found between Stimulus and Sagittal sites, $F(2,44) = 3.93$, $MSE = 58.97$, $p<.05$, and Sagittal and Coronal sites, $F(8,176) = 3.81$, $MSE = 38.63$, $p<.01$. A trend towards a significant interaction was found between Task and Stimulus, $F(1,22) = 4.73$, $MSE = 581.98$, $p=.05$, with amplitude being significantly greater for the face task when participants made incorrect pleasant ($M = 13.33\mu$V.) responses than unpleasant ($M = 8.31\mu$V.) responses to the neutral stimuli, however, no significant differences were found for the picture task, as participants responded similarly when answering pleasant or unpleasant to the neutral pictures.

LPC Latency: The five-way mixed ANOVA conducted on the LPC latency data for incorrect responses to neutral stimuli in both tasks showed that participants responded with significantly shorter LPC latency when making incorrect responses to neutral faces ($M = 539.40$ms.), than pictures ($M = 563.01$ms.), $F(1,22) = 12.12$, $MSE = 16441.09$, $p<.01$. A significant main effect was also found for Stimulus, $F(1,22) = 5.75$, $MSE = 11085.51$, $p<.05$. Pairwise comparisons showed that participants responded with significantly shorter LPC latency when making unpleasant responses to neutral faces and pictures ($M = 544.53$ms.) than when making pleasant responses ($M = 557.89$ms.). Additionally, significant main effects were found for Sagittal, $F(2,44) = 85.21$, $MSE = 2897.73$, $p<.001$ and Coronal sites, $F(4,88) = 4.72$, $MSE = 7254.19$, $p<.01$ however a significant main effect was not found for Group, $F(1,22) = 0.35$, $MSE = 35471.38$, $p>.05$.

These significant main effects were modified by significant two-way interactions between Task and Sagittal sites, $F(2,44) = 7.18$, $MSE = 8494.41$, $p<.01$, Task and Coronal sites, $F(4,88) = 3.06$, $MSE = 3900.41$, $p<.05$, and Sagittal and Coronal sites, $F(8,176) = 6.80$, $MSE = 7479.69$, $p<.001$. A trend towards a significant two-way interaction was found between Stimulus and Group, $F(1,22) = 3.57$, $MSE = 11085.51$, $p=.07$, as can be seen in Figure 17. Breakdown ANOVAs indicated that for the Control group there was a significant effect of Stimulus, $F(1,10) = 11.71$, $MSE = 8032.10$, $p<.02$, with participants responding with significantly shorter LPC latency when making unpleasant responses to neutral faces and pictures ($M = 544.25$ms.), than when making pleasant responses ($M = 568.13$ms.). In contrast, no significant differences were found for Stimulus for the BPT group. In addition, the Control group responded with significantly longer latency when making pleasant responses to the neutral faces and pictures than the BPT group but no significant differences were found between the groups for unpleasant responses ($p<.001$).

The significant two-way interactions were further modified by a significant three-way interaction between Task, Sagittal, and Coronal sites, $F(8,176) = 3.13$, $MSE = 5268.78$, $p<.02$, with latency being generally longer across all sites for the picture task, especially in parietal and central sites, across far left and far right coronal areas. In contrast, latency was longer for the face task in frontal and central sites across far left and far right coronal sites.

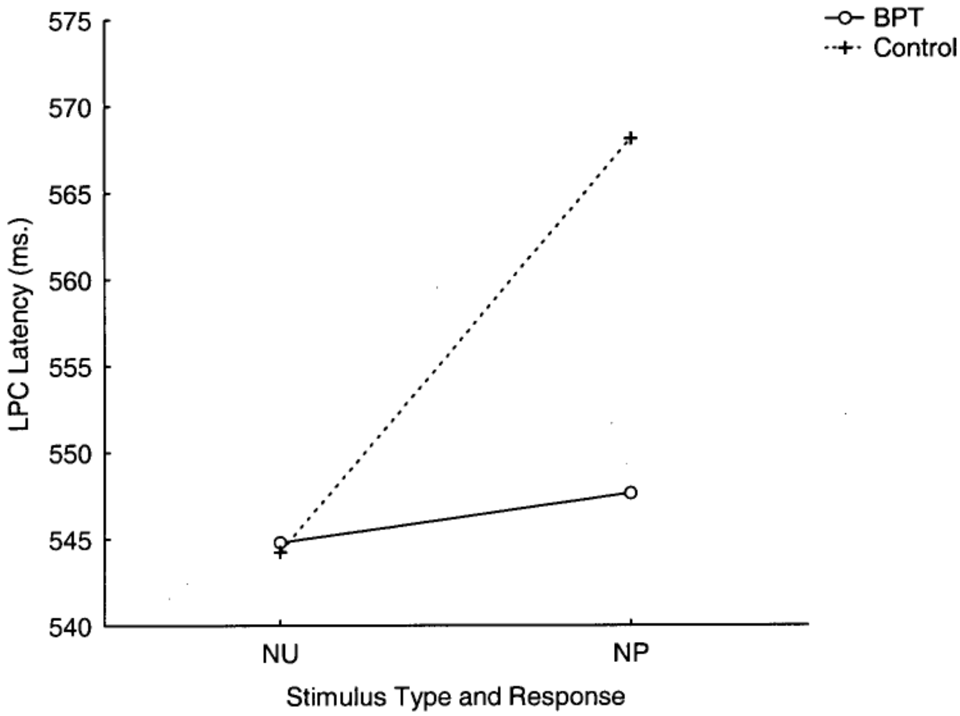

Figure 18. LPC latency for incorrect unpleasant (NU) and pleasant (NP) responses to neutral faces and pictures for the BPT and Control groups.

Summary of ERP Results

When making correct responses to faces and pictures, P300 amplitude was shown to be significantly greater for pleasant and unpleasant stimuli than neutral stimuli and irrespective whether participants responded correctly or incorrectly, the faces were found to elicit significantly greater P300 amplitude in both groups than the pictures. Group differences in P300 amplitude were shown when participants responded to the faces and pictures incorrectly but not when they responded correctly, as the control group displayed significantly grater P300 amplitude than the BPT group when making incorrect responses but no group differences were found for correct responses. P300 amplitude was generally larger across central Sagittal sites over the left, midline and right Coronal sites.

When making both correct and incorrect responses the BPT group were shown to respond with significantly shorter P300 latency than the control group. Longer P300 latency was shown for pleasant than unpleasant and neutral stimuli and for the pictures than the faces. P300 latency was also shown to be longer across frontal and central Sagittal sites.

LPC amplitude was found to be greater for unpleasant and pleasant faces and pictures than neutral faces and pictures for correct responses. No group differences were found for correct responses, however when responding incorrectly the BPT group were shown to exhibit significantly lower LPC amplitude than the control group. LPC amplitude was found to be greater across parietal Sagittal sites in the control group than the BPT group.

For correct responses, both groups were found to respond with longer LPC latency to pleasant pictures and faces than to unpleasant and neutral stimuli. In contrast, when responding incorrectly, both groups were shown to respond with significantly shorter latency to the faces than to pictures. LPC latency was also shown to be significantly shorter when participants incorrectly responded to neutral stimuli as being unpleasant than when they responded to neutral stimuli as being pleasant.

Discussion

The aim of this study was to investigate the neuropsychological basis for an emotional dysregulation theory of BPD, as proposed by researchers such as Linehan

(1993), by examining whether individuals with borderline traits (BPT group) would be more sensitive to emotional information than individuals with little or no borderline traits (control group). Specifically, this study aimed to investigate the contradiction in the literature where some researchers have found that BPD patients are more accurate at identifying emotional information than others (e.g., Frank & Hoffman, 1986) and other researchers have found that they are less accurate (e.g., Arntz & Veen, 2001). Hence, this study aimed to determine whether BPT individuals would exhibit different ERP responses to emotional material than controls, and whether BPT individuals would be more likely to misinterpret neutral emotional stimuli as being unpleasant than controls. Personality disorders are viewed by some researchers as existing on a continuum (e.g., Trull, 2005), with some people endorsing traits of a disorder but not meeting the full diagnostic criteria and experiencing clinical impairment. It was thus assumed that the BPT participants used in this study were exhibiting some traits of BPD and that they would respond to emotional material in a similar way to people with BPD and make similar errors in processing.

Following on from Linehan's (1993) biosocial theory, it was hypothesised that BPT individuals would be more sensitive to pleasant and unpleasant stimuli than controls and would thus respond with a faster reaction time to emotional pictures and faces than controls. This hypothesis was not supported by the results, as no group differences were found for reaction time with both the BPT and control groups responding with a similar reaction time to the stimuli in both tasks. Reaction time was, however, found to vary as a function of task and stimulus type. Reaction time was found to be significantly faster to faces than to pictures and to pleasant than unpleasant and neutral stimuli in the face task. This finding of a faster reaction time to the face stimuli than the pictures was probably due to the pictures containing a more ambiguous emotional content and thus requiring more time to process the emotional cues than the faces, and is in agreement with past research that has found that the mechanisms involved in the processing of faces are different to those involved in the processing of other stimuli (e.g., Balconi & Lucchiari, 2005). Supporting the result of a slower reaction time to unpleasant faces than neutral or pleasant, past research (e.g., Bradley et al., 1996) has shown that people take longer to process pictures with an emotional content, both pleasant and unpleasant, than neutral pictures.

Reflecting a heightened sensitivity to emotional cues, it was hypothesised that the BPT group would be more accurate at identifying the emotional content of the stimuli, by obtaining a higher percentage of correct responses than the controls. In contrast to this hypothesis, no group differences were found for accuracy for correct responses, in fact the BPT group were actually found to make significantly more incorrect responses to the neutral stimuli in both tasks than the control participants. Although, this result is in direct contradiction to research conducted by Wagner and Linehan (1999), which found that BPD patients were more accurate at identifying facial expressions of emotions than other people, it does support other research by Levine et al. (1997) and Bland et al. (2004), which found that BPD patients were less accurate at recognising emotions than controls.

The hypothesis that the BPT group would respond with greater P300 amplitude and shorter latency to stimuli than controls, because of an assumed emotional hypersensitivity, was supported. For correct responses, although no group differences were found for P300 amplitude, a trend was shown for the BPT group to respond with a shorter P300 latency overall to stimuli in both the picture and face tasks than the controls. Prior research with ERPs and emotions has found that healthy control individuals have greater P300 amplitude and longer latency when responding to pleasant and unpleasant stimuli, than neutral stimuli (e.g., Keil et al., 2002) reflecting assumed greater attentional resources (Lang et al., 1997), so it follows that if BPD patients are more sensitive to emotional material than people without BPD that they will exhibit greater amplitude and shorter latencies, because of an inability to take their time and block out an unconditioned sensitised response to the emotional stimuli. When responding incorrectly to neutral pictures and faces, the BPT group were found to respond with smaller P300 amplitude and shorter P300 latency than the control group, possibly indicating that they had applied less cognitive resources to processing the emotional information than the control participants and thus responded with a greater percentage of incorrect answers.

Consistent with the hypotheses, the BPT group were found to make more incorrect responses to the neutral faces and pictures than the control participants, although both groups were found to make incorrect responses to the neutral stimuli. A significant main effect for group was found, with the BPT group making more of both pleasant and unpleasant responses to the neutral stimuli than the control group. Interestingly, a significant main effect of task was also found, as participants made significantly more unpleasant responses to the neutral faces than pleasant responses but more pleasant responses to the neutral pictures than unpleasant. This result is supported by past research (e.g., Wagner & Linehan, 1999) in which it was found that BPD patients were more likely to misinterpret neutral faces as being unpleasant by ascribing the emotion of fear to neutral faces than controls. Furthermore, a trend towards a significant three-way interaction between Group, Task and Stimulus type was found indicating that both the BPT and control groups responded incorrectly significantly more often to neutral faces as unpleasant and neutral pictures as pleasant, but the BPT group were found to make more of these incorrect responses overall than the control group..

Clinicians have noted that when BPD patients are faced with ambiguous facial expressions or emotional cues (e.g., neutral emotional stimuli) they are prone to incorrectly ascribe a negative emotion or intention to the situation (e.g., Wagner & Linehan, 1990). This is seen to occur as a result of the BPD patient being treated badly by significant care-givers in their past (experiencing an invalidating environment) and thus now experiencing distrust of other people and displaying a heightened tendency to interpret other people's intentions as being malevolent, even when they are neutral in nature (e.g., Linehan, 1993). While the findings from this study support the contention that BPT individuals are more likely to incorrectly interpret neutral faces as being unpleasant, it does not explain why neutral pictures were incorrectly interpreted as pleasant more often than as unpleasant. It also must be noted that even though the BPT group made more incorrect responses to neutral stimuli than the control group, the control group also showed this pattern of responding to neutral faces as unpleasant and neutral pictures as pleasant. It may well be that the neutral pictures used in this study may have appeared more positive in nature than the neutral faces because they were shown in colour and the neutral pictures may have appeared more sombre or sad because of their black and white colour. Research has shown that colour has an effect on emotion (e.g., Kay & Epps, 2004). Alternatively, the neutral pictures may have contained more positive emotional cues in general than the neutral faces.

It was hypothesised that the control participants would respond with greater P300 and LPC amplitude and longer P300 and LPC latency to the emotional (pleasant and unpleasant) pictures and faces, than the neutral stimuli, as past research has found this pattern of ERP response in healthy adults to emotional information (e.g., Carretié et al., 1997; Schupp et al., 2003). Support for this hypothesis was found as the control group had longer P300 latency to pleasant and unpleasant stimuli than neutral stimuli and longer LPC latency to pleasant stimuli than neutral and unpleasant stimuli. In addition, P300 and LPC amplitude were found to be greater to pleasant and unpleasant stimuli than neutral, for both groups when responding correctly.

Support for the hypothesis that BPT individuals would respond to neutral stimuli similarly to emotional stimuli, because of a tendency to interpret neutral information as negative (e.g., Wagner & Linehan, 1999) was not found. The BPT group were found to respond with greater P300 and LPC amplitudes and longer P300 and LPC latencies to the unpleasant and pleasant stimuli compared to the neutral stimuli. Differences were however found between the response patterns of the two groups with the BPT group generally exhibiting overall shorter latencies and smaller amplitude than the control group. Although this finding of smaller amplitudes to stimuli in the BPT group is in contradiction to the hypothesis that BPT individuals would respond with greater amplitudes, reflecting a heightened sensitivity to emotional information, it is in agreement with auditory evoked ERP studies conducted with BPD participants (e.g., Blackwood et al., 1986). Earlier studies conducted using both auditory evoked ERPs (e.g., Kutcher at al., 1987; Kutcher et al., 1989) and visually evoked ERPs (e.g., Houston et al., 2004) with non-emotional stimuli have consistently shown a pattern of decreased P300 amplitude in BPD patients compared with people without BPD. Interestingly, BPD patients have also been shown to exhibit longer latencies in these studies than people without BPD however in our research the BPT group consistently had shorter latencies to stimuli than the controls. One possible explanation for this finding may be that the past ERP studies of BPD patients did not employ emotional material and research examining emotional processing in healthy control participants has generally shown that latencies are longer for emotional material than non-emotional (neutral) material, reflecting assumed extra processing resources being applied when responding to the emotional material (e.g., Schupp et al., 2003). It thus follows, that if BPT individuals respond to emotional material differently to controls, and if they make more incorrect responses (misidentifying neutral stimuli as pleasant or unpleasant) they may be applying less attentional resources to processing the stimuli and will thus exhibit shorter LPC and P300 latencies, than control participants.

As hypothesised, reaction time was found to be shorter for faces than pictures and LPC and P300 latency was found to be longer for pictures than faces.

Furthermore, in support of past research, P300 and LPC amplitude were found to be greater for faces than pictures (e.g., Holmes et al., 2003). The BPT group however were not more sensitive to faces than the control group, as predicted, as although the BPT group had shorter ERP latencies than the control group, this was the case for stimuli in the picture task as well as the face task and the BPT group, in general, had lower amplitude rather than greater amplitude to the faces than the control group.

In summary, this research has shown that people endorsing borderline symptomatology do respond to emotional information differently compared to people who endorse few or no borderline traits. Although these differences in response did not always follow the hypotheses, distinct differences were clearly demonstrated. Firstly, the BPT group were found to respond with overall shorter P300 and LPC latencies to pictures and faces, when responding both correctly and incorrectly than control participants. Although past research involving BPD patients has generally reported longer latencies in this clinical group (e.g., Kutcher et al., 1989), it must be remembered that these past studies did not employ emotional information and it can therefore be assumed that the shorter latencies found in this study were responses specific to emotional material. Studies examining the ERP responses of healthy individuals to emotional material have generally reported longer latencies to emotional stimuli than neutral stimuli (e.g., Cuthbert et al., 2000). Thus the finding of shorter latencies of BPT individuals than controls in this study may reflect a weakened amount of attentional resources being applied to emotional material by the BPT group and this can be assumed to be impacting on their ability to interact interpersonally with other people.

Secondly, distinct differences between the two groups were also demonstrated for P300 and LPC amplitude. When making incorrect responses to the neutral faces and pictures, the BPT group were found to demonstrate overall smaller LPC and P300 amplitudes than the control group, however when making correct responses no significant differences in amplitude were found. In previous research examining the ERPs of BPD patients it has generally been found that amplitudes are smaller in BPD patients than controls (e.g., Houston et al., 2004) and research involving ERP responses to emotional material in controls has generally found greater amplitude to emotional stimuli then neutral stimuli (e.g., Keil et al., 2002). It thus follows that the BPT group may have demonstrated smaller amplitudes when incorrectly processing neutral faces because of fewer attentional resources being applied to the stimuli and thus more misappraisals occurred.

Another important distinction found between BPT and control participants in this study was the finding of overall more inaccurate responses to both pictures and faces by the BPT group than the control group. Past research by Wagner and Linehan (1999) suggested that BPD patients may be just as accurate at identifying emotional expressions as other people but may be less accurate at identifying neutral facial expressions with a particular tendency to misinterpret neutral facial expressions as being negative. This research supports this hypothesis, as both groups were found to be just as accurate at correctly identifying pleasant and unpleasant stimuli and the BPT group were shown to make significantly more pleasant and unpleasant responses to the neutral stimuli than the control group however they did not make significantly more unpleasant responses than pleasant to the neutral stimuli.

This research also showed a difference in response to faces and pictures, which is in agreement with the results of previous research (e.g., Holmes et al., 2003). Interestingly the BPT group were not found to be more sensitive to faces than the control group as one would expect based on the theory of interpersonal sensitivity underlying BPD (e.g., Linehan, 1993). This suggests that BPD patients may respond to all emotional information differently, not just emotional information involving an interpersonal context.

Significant differences between responses to emotional material between the two groups were found despite the fact that the groups only contained small numbers of participants (BPT n = 15; control n = 15) and the experimental participants endorsed borderline traits rather than meeting the full diagnostic criteria for the condition. This suggests that had this study investigated larger numbers of participants and recruited participants that met the full diagnostic criteria for BPD these differences in response may have been much larger, and more variation in response may have been demonstrated. Alternatively, the differences between the two groups may have occurred as a result of the participants who were selected for the Control group endorsing little or no BPD traits and thus having less BPD symptomatology that what would be usual in the general population. It may thus be useful to get an understanding of what is usual in terms of BPD traits in the standard population and rule out participants who score too low in future research.

Future research in the area using a larger number of participants and participants who do meet the full diagnostic criteria for BPD, rather than those who exhibit milder traits, would be interesting to allow comparison between the groups and to determine if these differences in emotional interpretation are greater or vary with symptom severity. However, as noted earlier in this study, it can be very difficult to recruit BPD participants who do not suffer from a co-occurring Axis I condition and who are not taking any psychotropic medication and although care was taken in this research, some participants were included who were on medication for a depressive condition. This may have influenced responses to emotional material in this study, and it is therefore, necessary for future research to apply more stringent selection methods when recruiting participants.

It would also be useful for future research to examine further the tendency of BPD patients to misinterpret neutral information as being negative (e.g., Wagner & Linehan, 1999) as in this study only partial support for this tendency was found. The BPT group were found to respond incorrectly to neutral pictures more often as being pleasant and to neutral faces more often as being unpleasant. However, the control group were also found to respond in a similar manner when making incorrect responses to neutral stimuli, they just did so less often. This tendency to interpret neutral pictures as being pleasant and neutral faces as being unpleasant may be due to the fact that the pictures were presented in colour and the faces were presented in black and white, as colour has been shown to affect emotional appraisals (Kay & Epps, 2004), or it may have been due to the neutral pictures containing more pleasant emotional cues than the neutral faces, as the pictures contained more informational cues in general than the faces. It would thus be useful for future research to employ a range of neutral emotional information, in colour and black and white, with and without interpersonal cues to examine this assumed tendency of BPD patients to be more likely to interpret neutral information as being negative further.

Conclusions

This research aimed to examine the neuropsychological basis for Linehan's (1993) biosocial theory of BPD by investigating the differences in ERP responses of BPT individuals and controls. Linehan proposes that the problematic behaviours symptomatic of BPD (e.g., interpersonal problems, impulsivity, and self-harm) are caused by the BPD patient being unable to regulate their emotions adequately to suit their environment, a condition she labels 'emotional dysregulation'. BPD patients are viewed by Linehan as possessing an underlying vulnerability to emotional information and are seen to be overly sensitive to emotional cues in their environment (especially negative emotional cues). They are thus assumed to have a low tolerance for emotional reactivity and this is believed to lead them to react with a faster unconditioned response to emotional cues.

This investigation showed that people who endorse BPD traits, and who thus experience a mild form of the disorder, do interpret emotional material differently to people without BPD. Neuropsychological differences were found between the responses of BPT participants and controls as the BPT group were found to respond with smaller LPC and P300 amplitudes when responding incorrectly to emotional stimuli than controls which was interpreted as reflecting a weakened amount of attentional resources being applied to processing the emotional stimuli by the BPT group. In addition, LPC and P300 latencies were faster in BPT participants when responding correctly and incorrectly, suggesting a faster unconditioned response to emotional cues in this group of participants. Neuropsychological support was thus provided for Linehan's (1993) biosocial theory of BPD.

References

American Psychiatric Association (2000). *Diagnostic and Statistical Manual of Mental Disorders (4^{th} Ed. Text Revision).* Washington: American Psychiatric Association.

Balconi, M., & Lucchiari, C. (2005). Event-related potentials related to normal and morphed emotional faces. *The Journal of Psychology, 139*, 176-192.

Blackwood, D.H.R., St Clair, D.M., & Kutcher, S.P. (1986). P300 event-related potential abnormalities in BPD. *Biological Psychiatry, 21*, 557-560.

Bland, A.R., Williams, C.A., Scharer, K., & Manning, S. (2004). Emotional processing in borderline personality disorders. *Issues in Mental Health Nursing, 25*, 655-672.

Boutros, N.N., Torello, M., & McGlashan, T.H. (2003). Electrophysiological aberrations in BPD: State of the evidence. *Journal of Neuropsychiatry and Clinical Neurosciences, 15*, 145-154.

Bradley, M.M., Cuthbert, B.N., & Lang, P.J. (1996). Picture media and emotion: Effects of a sustained affective context. *Psychophysiology, 33*, 662-670.

Bradley, M.M., & Lang, P.J. (1994). Measuring emotion: The self-assessment manikin and the semantic differential. *Journal of Behaviour Therapy and Experimental Psychiatry, 25*, 49-59.

Carretié, L., Iglesias, J., & García, T. (1997). A study of the emotional processing of visual stimuli through event-related potentials. *Brain and Cognition, 34*, 207-217.

Clarkin, J.F., Levy, K.N., Lenzenweger, M.F., & Kernberg, O.F. (2004). The personality disorders institute/ borderline personality disorder research foundation randomised control trial for borderline personality disorder: Rationale, methods and patient characteristics. *Journal of Personality Disorders, 18*, 52-72.

Cuthbert, B.N., Schupp, H.T., Bradley, M.M., Birbaumer, W., & Lang, P.J. (2000). Brain potentials in affective picture processing; Covariation with autonomic arousal and affective report. *Biological Psychiatry, 52,* 95-111.

Dodge, K.A. (1991). Emotion and social information processing. In J. Garber & K.A. Dodge (Eds.), *The development of emotion regulation and dysregulation* (pp.159-181). Cambridge: Cambridge University Press.

Ekman, P., & Friesen, W.V. (1976). *Pictures of Facial Affect.* Palo Alto, California: Consulting Psychologists Press.

Empson, J. (1986). *Human Brainwaves: The Psychological Significance of the Electroencephalogram.* New York: Stockton Press.

Figueroa, E., & Silk, K.R. (1997). Biological implications of childhood sexual abuse in borderline personality disorder. *Journal of Personality Disorders, 11*, 71-92.

Frank, H., & Hoffman, N. (1986). Borderline empathy: an empirical investigation. *Comprehensive Psychiatry, 27*, 387-395.

Graham, R., & Cabeza, R. (2001). Event-related potentials of recognising happy and neutral faces. *Neuroreport, 12*, 245-248.

Greenwald, M.K., Cook, E.W., & Lang, P.J. (1989). Affective judgment and psychophysiological response: Dimensional covariation in the evaluation of pictoral stimuli. *Journal of Psychophysiology, 3*, 51-64.

Holmes, A., Vuilleumier, P., & Eimer, M. (2003). The processing of emotional facial expression is gated by spatial attention: Evidence from event-related brain potentials. *Cognitive Brain Research, 16*, 174-184.

Houston, R.J., Bauer, L.O., & Hesselbrock, V.M. (2004). Effects of borderline personality disorder features and a family history of alcohol or drug dependence on P300 in adolescents. *International Journal of Psychophysiology, 53*, 57-70.

Johnston, V.S., & Oliver-Rodriguez, J.C. (1997). Facial beauty and the late positive component of event-related potentials. *The Journal of Sex Research, 34*, 188-198.

Kay, N., & Epps, H.H. (2004). Relationship between color and emotion: A study of college students. *College Student Journal, 38*, 396-405.

Keil, A., Bradley, M.M., Hauk, O., Rockstroh, B., Elbert, T., & Lang, P.J. (2002). Large-scale neural correlates of affective picture processing. *Psychophysiology, 39*, 641-649.

Krolak-Salmon, P., Fischer, C., Vighetto, A., & Mauguiére, F. (2001). Processing of facial emotional expression: Spatio-temporal data as assessed by scalp event-related potentials. *European Journal of Neuroscience, 13*, 987-994.

Kutcher, S.P., Blackwood, D.H.R., Gaskell, D.F., Muir, W.J., & St Clair, D.M. (1989). Auditory P300 does not differentiate BPD from schizotypal personality disorder. *Biological Psychiatry, 26*, 766-774.

Kutcher, S.P., Blackwood, D.H.R., St Clair, D., Gaskell, D.F., & Muir, W.J. (1987). Auditory P300 in BPD and schizophrenia. *Archives of General Psychiatry, 44*, 645-650.

Ladisich, W., & Feil, W.B. (1988). Empathy in psychiatric patients. *British Journal of Medical Psychiatry, 61*, 155-162.

Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (1990). Emotion, attention and the startle reflex. *Psychological Review, 97*, 377-395.

Lang, P.J., Bradley, M.M., & Cuthbert, B.N. (1999). *International Affective Picture System (IAPS): Instruction Manual and Affective ratings.* University of Florida, USA: The Centre for Research in Psychophysiology.

Levine, D., Marziali, E., & Hood, J. (1997). Emotion processing in BPDs. *The Journal of Nervous and Mental Disease, 185*, 240-246.

Lincoln, A.J., Bloom, D., Katz, M., & Boksenbaum, N. (1998). Neuropsychological and neurophysiological indices of auditory processing impairment in children with multiple complex developmental disorder. *Journal of the American Academy of Child and Adolescent Psychiatry, 37*, 100-112.

Linehan, M.M. (1993). *Cognitive-Behavioural Treatment of Borderline Personality Disorder.* New York: Guilford Press.

Millon, T., Davies, R., & Millon, C. (1997). *Millon Clinical Multiaxial Inventory-III.* USA: National Computer Systems.

Mufson, L., & Nowicki, S. (1991). Factors affecting the accuracy of facial affect recognition. *Journal of Social Psychology, 131*, 815-822.

Sansone, R.A., & Levitt, J.L. (2005). Borderline personality and eating disorders. *Eating Disorders, 13*, 71-83.

Schupp, H.T., Junghöfer, M., Weike, A.I., & Hamm, A.O. (2003). Attention and emotion: An ERP analysis of facilitated emotional stimulus processing. *Neuroreport, 14*, 1107-1110.

Smith, D.P., Hillman, C.H., & Duley, A.R. (2005). Influence of age on emotional reactivity during picture processing. *The Journals of Gerontology, 60B,* 49-56.

Trull, T.J. (2005). Dimensional models of personality disorder: Coverage and cutoffs. *Journal of Personality Disorders, 19*, 262-283.

Wagner, A.W., & Linehan, M.M. (1999). Facial expression recognition ability among women with BPD: Implications for emotion regulation? *Journal of Personality Disorders, 13*, 329-344.

Westen, D. (1991). Cognitive-behavioural interventions into psychoanalytic psychotherapy of borderline personality disorders. *Clinical Psychology Review, 11*, 211-230.

Zanarini, M.C., Vujanovic, A.A., Parachini, E.A., Boulanger, J.L., Frankenburg, F.R., & Hennen, J. (2003). A screening measure for BPD: The McLean screening instrument for borderline personality disorder (MSI-BPD). *Journal of Personality Disorders, 17*, 568-573.

Table of Appendices

Appendix A

Zanarini, Vujanovic, Parachini, Boulanger, Frankenburg, & Henner (2003)

McLean Screening Instrument for Borderline Personality Disorder: MSI-BPD.

Instructions: *below are 10 statements that describe some ways in which people may express emotions and deal with other people. Try and be as* ***honest*** *and* ***serious*** *as you can when responding to each statement. Please answer* ***every*** *question, by* ***circling 'Yes'*** *if the statement* ***applies to you****, or is true for you, or* ***'No'*** *if the statement* ***does not apply to you****, or describe your experiences. Remember to fill in your name, contact phone number, age and sex on the bottom of the form, once you have responded to each question, and then place the completed form in the box outside Sue Ross's office labelled* ***'Kristy's Personality Study'****.*

1. Have any of your closest relationships been troubled by a lot of arguments or repeated break-ups? **Yes** **No**

2. Have you ever deliberately hurt yourself physically (e.g., punched yourself, cut yourself, or burned yourself)? How about made a suicide attempt? **Yes** **No**

3. Have you had at least two other problems with impulsivity (e.g., eating binges, spending sprees, drinking too much and verbal outbursts)? **Yes** **No**

4. Have you often been extremely moody? **Yes** **No**

5. Have you felt very angry a lot of the time? How about often acted in an angry or sarcastic manner? **Yes** **No**

6. Have you often been distrustful of other people? **Yes** **No**

7. Have you frequently felt unreal or as if things around you were unreal? **Yes** **No**

8. Have you felt empty a lot of the time? **Yes** **No**

9. Have you often felt that you had no idea of who you are or that you have no identity? **Yes** **No**

10. Have you made efforts to avoid feeling abandoned or being abandoned by someone (e.g., repeatedly calling someone to reassure yourself that he or she still cared, begged them not to leave you, or clung to them physically)? **Yes** **No**

Name: **Contact Phone number:**

Age: **Sex:**

Thank you for your help.

Appendix B

Millon, Davies, & Millon (1997) ***Millon Clinical Multiaxial Inventory-III***

1. Lately, my strength seems to be draining out of me, even in the morning.

2. I think highly of rules because they are a good guide to follow.

3. I enjoy doing so many different things that I can't make up my mind what to do first.

4. I feel weak and tired much of the time.

5. I know I'm a superior person, so I don't care what people think.

6. People have never given me enough recognition for the things I've done.

7. If my family puts pressure on me, I'm likely to feel angry and resist doing what they want.

8. People make fun of me behind my back, talking about the way I act or look.

9. I often criticise people strongly if they annoy me.

10. What few feelings I seem to have I rarely show to the outside world.

11. I have a hard time keeping my balance when walking.

12. I show my feelings easily and quickly.

13. My drug habits have often gotten me into a good deal of trouble in the past.

14. Sometimes I can be pretty rough and mean in my relations with my family.

15. Things that are going well today won't last very long.

16. I am a very agreeable and submissive person.

17. As a teenager, I got into lots of trouble because of bad school behaviour.

18. I'm afraid to get really close to another person because it may end up with me being ridiculed or shamed.

19. I seem to choose friends who end up maltreating me.

20. I've had sad thoughts much of my life since I was a child.

21. I like to flirt with members of the opposite sex.

22. I'm a very erratic person, changing my mind and feelings all the time.

23. Drinking alcohol has never caused me any real problems in my work.

24. I began to feel like a failure some years ago.

25. I feel guilty much of the time for no reason that I know.

26. Other people envy my abilities.

27. When I have a choice, I prefer to do things alone.

28. I think it's necessary to place strict controls on the behaviour of members of my family.

29. People usually think of me as a reserved and serious-minded person.

30. Lately, I have begun to feel like smashing things.

31. I think I'm a special person who deserves special attention from others.

32. I am always looking to make new friends and meet new people.

33. If someone criticised me for making a mistake, I would quickly point out some of that person's mistakes.

34. Lately, I have gone all to pieces.

35. I often give up doing things because I'm afraid I won't do them well.

36. I often let my angry feelings out and then feel terribly guilty about it.

37. I very often lose my ability to feel any sensations in parts of my body.

38. I do what I want without worrying about its effect on others.

39. Taking so-called illegal drugs may be unwise, but in the past I found I needed them.

40. I guess I'm a fearful and inhibited person.

41. I've done a number of stupid things on impulse that ended up causing me great trouble.

42. I never forgive an insult or forget an embarrassment that someone caused me.

43. I often feel sad or tense right after something good has happened to me.

44. I feel terribly depressed and sad much of the time now.

45. I always try hard to please others, even when I dislike them.

46. I've always had less interest in sex than most people do.

47. I tend to always blame myself when things go wrong.

48. A long time ago, I decided it's best to have little to do with people.

49. Since I was a child, I have always had to watch out for people who were trying to cheat me.

50. I strongly resent "big shots" who always think they can do tings better than I can.

51. When things get boring, I like to stir up some excitement.

52. I have an alcohol problem that has made difficulties for me and my family.

53. Punishment never stopped me from doing what I wanted.

54. There are many times, when for no reason, I feel very cheerful and full of excitement.

55. In recent weeks I feel worn out for no special reason.

56. For some time now I've been feeling very guilty because I can't do things right anymore.

57. I think I am a sociable and very outgoing person.

58. I've become very jumpy in the last few weeks.

59. I keep very close track of my money so I am prepared if a need comes up.

60. I just haven't had the luck in life that others have had.

61. Ideas keep turning over and over in my mind and they won't go away.

62. I've become quite discouraged and sad about life in the past year or two.

63. Many people have been spying into my private life for years.

64. I don't know why, but I sometimes say cruel things just to make others unhappy.

65. I flew across the Atlantic 30 times last year.

66. My habit of abusing drugs has caused me to miss work in the past.

67. I have many ideas that are ahead of the times.

68. Lately, I have to think things over and over again for no reason.

69. I avoid most social situations because I expect people to criticise or reject me.

70. I often think that I don't deserve the good things that happen to me.

71. When I'm alone, I often feel the strong presence of someone nearby who can't be seen.

72. I feel pretty aimless and don't know where I'm going in life.

73. I often allow others to make important decisions for me.

74. I can't seem to sleep, and wake up just as tired as when I went to bed.

75. Lately, I've been sweating a great deal and feel very tense.

76. I keep having strange thoughts that I wish I could get rid of.

77. I have a great deal of trouble trying to control an impulse to drink to excess.

78. Even when I'm awake, I don't seem to notice people who are near me.

79. I am often cross and grouchy.

80. It is very easy for me to make many friends.

81. I'm ashamed of some of the abuses I suffered when I was young.

82. I always make sure that my work is well planned and organised.

83. My moods seem to change a great deal from one day to the next.

84. I'm too unsure of myself to risk trying something new.

85. I don't blame anyone for taking advantage of someone who allows it.

86. For some time now I've been feeling sad and blue and can't seem to snap out of it.

87. I often get angry with people who do things slowly.

88. I never sit on the sidelines when I'm at a party.

89. I watch my family closely so I'll know who can and who can't be trusted.

90. I sometimes get confused and feel upset when people are kind to me.

91. My use of so-called illegal drugs has led to family arguments.

92. I'm alone most of the time and I prefer it that way.

93. There are members of my family who say I'm selfish and think only of myself.

94. People can easily change my ideas, even if I thought my mind was made up.

95. I often make people angry by bossing them.

96. People have said in the past that I became too interested and too excited about too many things.

97. I believe in the saying, "early to bed and early to rise..."

98. My feelings toward important people in my life often swing from loving them to hating them.

99. In social groups I am almost always very self-conscious and tense.

100. I guess I'm no different from my parents in becoming somewhat of an alcoholic.

101. I guess I don't take many of my family responsibilities as seriously as I should.

102. Ever since I was a child, I have been losing touch with the real world.

103. Sneaky people often try to get the credit for things I have done or thought of.

104. I don't experience much pleasure because I don't feel I deserve it.

105. I have little desire for close friendships.

106. I've had many periods in my life when I was so cheerful and used up so much energy that I fell into a low mood.

107. I have completely lost my appetite and have trouble sleeping most nights.

108. I worry a great deal about being left alone and having to take care of myself.

109. The memory of a very upsetting experience in my past keeps coming back to haunt my thoughts.

110. I was on the front cover of several magazines last year.

111. I seem to have lost interest in most things that I used to find pleasurable, such as sex.

112. I have been downhearted and sad much of my life since I was quite young.

113. I've gotten in trouble with the law a couple of times.

114. A good way to avoid mistakes is to have a routine for doing things.

115. Other people often blame me for things I didn't do.

116. I have had to be really rough with some people to keep them in line.

117. People think I sometimes talk about strange or different things than they do.

118. There have been times when I couldn't get through the day without some street drugs.

119. People are trying to make me believe that I'm crazy.

120. I'll do something desperate to prevent a person I love from abandoning me.

121. I go on eating binges a couple of times a week.

122. I seem to make a mess of good opportunities that come my way.

123. I've always had a hard time stopping myself from feeling blue and unhappy.

124. When I'm alone and away from home, I often begin to feel tense and panicky.

125. People sometimes get annoyed with me because they say I talk too much or too fast for them.

126. Most successful people today have been either lucky or dishonest.

127. I won't get involved with people unless I'm sure they'll like me.

128. I feel deeply depressed for no reason I can figure out.

129. Years later I still have nightmares about an event that was a real threat to my life.

130. I don't have the energy to concentrate on my everyday responsibilities anymore.

131. Drinking alcohol helps when I'm feeling down.

132. I hate to think about some of the ways I was abused as a child.

133. Even in good times, I've always been afraid that things would soon go bad.

134. I sometimes feel crazy-like or unreal when things start to go badly in my life.

135. Being alone, without the help of someone close to depend on, really frightens me.

136. I know I've spent more money than I should buying illegal drugs.

137. I always see to it that my work is finished before taking time out for leisure activities.

138. I can tell that people are talking about me when I pass by them.

139. I'm very good at making up excuses when I get into trouble.

140. I believe I'm being plotted against.

141. I feel that most people think poorly of me.

142. I frequently feel there's nothing inside me, like I'm empty and hollow.

143. I sometimes force myself to vomit after eating.

144. I guess I go out of my way to encourage people to admire the things I say or do.

145. I spend my life worrying over one thing another.

146. I always wonder what the real reason is when someone is being especially nice to me.

147. There are certain thoughts that keep coming back again and again in my mind.

148. Few things in life give me pleasure.

149. I feel shaky and have difficulty falling asleep because painful memories of a past event keep running through my mind.

150. Looking ahead as each day begins makes me feel terribly depressed.

151. I've never been able to shake the feeling that I'm worthless to others.

152. I have a drinking problem that I've tried unsuccessfully to end.

153. Someone has been trying to control my mind.

154. I have tried to commit suicide.

155. I'm willing to starve myself to be even thinner than I am.

156. I don't understand why some people smile at me.

157. I have not seen a car in the last ten years.

158. I get very tense with people I don't know well because they may want to hurt me.

159. Someone would have to be pretty exceptional to understand my special abilities.

160. My current life is still upset by flashbacks of something terrible that happened to me.

161. I seem to create situations with others in which I get hurt or feel rejected.

162. I often get lost in my thoughts and forget what's going on around me.

163. People say I'm a thin person, but I feel that my thighs and backside are much too big.

164. There are terrible events from my past that come back repeatedly to haunt my thoughts and dreams.

165. Other than my family, I have no close friends.

166. I act quickly much of the time and don't think things through as I should.

167. I take great care to keep my life a private matter so no one can take advantage of me.\

168. I very often hear things so well that it bothers me.

169. I'm always willing to give in to others in a disagreement because I fear their anger or rejection.

170. I repeat certain behaviours again and again, sometimes to reduce my anxiety and sometimes to stop something bad from happening.

171. I have given \serious thought recently to doing away with myself.

172. People tell me that I'm a very proper and moral person.

173. I still feel terrified when I think of a traumatic experience that I had years ago.

174. Although I'm afraid to make friendships, I wish I had more than I do.

175. There are people who are supposed to be my friends who would like to do me harm.

Appendix C

Background Medical Questionnaire.

ERP Responses to Emotional Material as a Function of Personality Traits

Medical and History Questionnaire[1]

University of Tasmania
School of Psychology

Date……/……./…….

Participant Code……………………………….

Medical History
Are you currently suffering from anxiety or depression?……………………………………………….

Do you have a heart condition or any other serious physical condition?

………

Are you currently taking any prescription medication? If so, what medication?

………

Have you in the past taken any medications for psychological condition(s)? If so, what medications?

………

Have you ever had, or are you now suffering from, any of the following (please circle):

Fits or convulsions	*Yes*	*No*
Epilepsy	*Yes*	*No*
Giddiness	*Yes*	*No*
Concussion	*Yes*	*No*
Severe Head Injury	*Yes*	*No*
Loss of Consciousness	*Yes*	*No*

Drinking and Smoking History
On how many days last week did you drink alcohol?

None
One or two days
Three or four days
Five or six days
Every day

Do you usually drink...

Never
During weekdays
Friday night
Weekends

How many drinks would you usually have at one time?

One or two
Three to five

	Five to eight Eight to twelve More than twelve	
Do you get drunk?	Never Rarely Once a month Once a week More frequently	
How often do you smoke a cigarette?	Never Less than 5 per week Less than 5 per day 5 to 9 per day 10 to 19 per day 20 to 39 per day Over 40 per day	
Do you or have you in the past used marijuana? (please circle)	*Yes*	*No*
a) Have you used marijuana in the last two weeks?	*Yes*	*No*
b) Have you used any other form of illicit drug in the last 6 months?	*Yes*	*No*

Vision
Do you have any difficulties with vision? (please specify)

....

If yes, are these difficulties corrected (i.e. glasses/contacts)

....

Note: It is a formal requirement of the Human Research Ethics Committee (Tasmania) Network that the information provided on this questionnaire be held under security to comply with confidentiality regulations and to protect your privacy. You can be assured that information will be available only to the principal researcher and not to any other party. This questionnaire will be destroyed following selection of volunteers for the project.

Thank you for your Participation

Appendix D

Repeated Measures ANOVAs for BPT medicated and BPT no medication Groups.

Behavioural Data

Picture Task: Reaction Time for Correct Responses

Test of Within-Subjects Effects

Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Stimulus*Group	2	0.007	1.097	0.34
Error (Stimulus)	26	0.007		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	0.075	1.475	0.25
Error	13	0.051		

Picture Task: Accuracy for Correct and Incorrect Responses

Test of Within-Subjects Effects

Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Stimulus*Group	8	2149.654	2.325	0.12
Error (Stimulus)	104	207.430		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	7.320	0.091	0.77
Error	13	80.305		

Face Task: Reaction Time for Correct Responses

Test of Within-Subjects Effects

Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Stimulus*Group	2	0.008	0.980	0.34
Error (Stimulus)	26	0.008		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	0.002	0.030	0.87
Error	13	0.054		

Face Task: Accuracy for Correct and Incorrect Responses
Test of Within-Subjects-Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Stimulus*Group	8	1118.375	0.731	0.47
Error (Stimulus)	104	1529.258		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	26.678	0.249	0.63
Error	13	107.306		

Event-Related Potential Data

Picture Task: P300 Amplitude Correct Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Stimulus*Group	2	39.747	1.057	0.35
Error (Stimulus)	26	37.589		
Sagittal*Group	2	33.477	0.197	0.72
Error (Sagittal)	26	170.048		
Coronal*Group	4	63.955	2.167	0.11
Error (Coronal)	52	29.519		
Stimulus*Sagittal*Group	4	4.275	0.214	0.82
Error (Stimulus*Sagittal)	52	19.993		
Stimulus*Coronal*Group	8	9.863	1.566	0.19
Error (Stimulus*Coronal)	104	6.297		
Sagittal*Coronal*Group	8	17.973	0.619	0.63
Error (Sagittal*Coronal)	104	29.047		
Stimulus*Sagittal*Coronal*Group	16	2.663	0.716	0.64
Error (Stimulus*Sagittal*Coronal)	208	3.722		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	1141.685	4.366	0.06
Error	13	261.475		

Picture Task: P300 Amplitude Incorrect responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Stimulus*Group	1	5.238	0.047	0.83
Error (Stimulus)	13	110.654		
Sagittal*Group	2	90.069	0.644	0.46
Error (Sagittal)	26	139.881		
Coronal*Group	4	89.104	3.014	0.06
Error (Coronal)	52	29.566		
Stimulus*Sagittal*Group	2	11.357	0.909	0.41
Error (Stimulus*Sagittal)	26	12.498		
Stimulus*Coronal*Group	4	17.781	0.829	0.42
Error (Stimulus*Coronal)	52	21.456		
Sagittal*Coronal*Group	8	7.532	0.422	0.78
Error (Sagittal*Coronal)	104	17.863		
Stimulus*Sagittal*Coronal* Group	8	6.817	0.547	0.60
Error (Stimulus*Sagittal* Coronal	104	12.454		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	723.710	2.682	0.13
Error	13	269.807		

Picture Task: LPC Amplitude Correct Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Stimulus*Group	2	81.047	2.007	0.16
Error (Stimulus)	26	40.387		
Sagittal*Group	2	79.267	0.674	0.46
Error (Sagittal)	26	117.573		
Coronal*Group	4	23.966	0.438	0.68
Error (Coronal)	52	54.763		
Stimulus*Sagittal*Group	4	10.190	0.540	0.62
Error (Stimulus*Sagittal)	52	18.862		
Stimulus*Coronal*Group	8	14.384	0.821	0.50
Error (Stimulus*Coronal)	104	17.517		
Sagittal*Coronal*Group	8	13.378	0.398	0.76
Error (Sagittal*Coronal)	104	33.614		
Stimulus*Sagittal*Coronal* Group	16	9.732	1.274	0.28
Error (Stimulus*Sagittal* Coronal	208	7.636		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	372.263	1.387	0.26
Error	13	268.437		

Picture Task: LPC Amplitude Incorrect Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Stimulus*Group	1	1.644	0.025	0.88
Error (Stimulus)	13	64.832		
Sagittal*Group	2	74.724	0.547	0.52
Error (Sagittal)	26	136.724		
Coronal*Group	4	46.466	0.712	0.51
Error (Coronal)	52	65.261		
Stimulus*Sagittal*Group	2	2.045	0.041	0.90
Error (Stimulus*Sagittal)	26	50.074		
Stimulus*Coronal*Group	4	30.263	3.229	0.03
Error (Stimulus*Coronal)	52	9.373		
Sagittal*Coronal*Group	8	14.595	0.678	0.59
Error (Sagittal*Coronal)	104	21.523		
Stimulus*Sagittal*Coronal*Group	8	4.397	0.912	0.46
Error (Stimulus*Sagittal*Coronal)	104	4.820		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	549.222	1.755	0.21
Error	13	312.859		

Face Task: P300 Amplitude Correct Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Stimulus*Group	2	24.549	0.784	0.47
Error (Stimulus)	26	31.311		
Sagittal*Group	2	181.532	0.831	0.39
Error (Sagittal)	26	218.502		
Coronal*Group	4	64.049	3.627	0.03
Error (Coronal)	52	17.659		
Stimulus*Sagittal*Group	4	72.401	2.469	0.10
Error (Stimulus*Sagittal)	52	29.319		
Stimulus*Coronal*Group	8	20.831	1.033	0.38
Error (Stimulus*Coronal)	104	20.157		
Sagittal*Coronal*Group	8	15.422	1.174	0.33
Error (Sagittal*Coronal)	104	13.136		
Stimulus*Sagittal*Coronal* Group	16	5.817	0.545	0.68
Error (Stimulus*Sagittal* Coronal	208	10.672		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	683.645	2.393	0.15
Error	13	285.707		

Face Task: P300 Amplitude Incorrect Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Stimulus*Group	1	166.562	0.407	0.54
Error (Stimulus)	11	409.519		
Sagittal*Group	2	115.821	0.641	0.46
Error (Sagittal)	22	180.602		
Coronal*Group	4	110.367	2.186	0.15
Error (Coronal)	44	50.484		
Stimulus*Sagittal*Group	2	6.326	0.092	0.82
Error (Stimulus*Sagittal)	22	68.840		
Stimulus*Coronal*Group	4	12.5222	1.105	0.36
Error (Stimulus*Coronal)	44	11.328		
Sagittal*Coronal*Group	8	31.658	1.610	0.20
Error (Sagittal*Coronal)	88	19.658		
Stimulus*Sagittal*Coronal* Group	8	15.785	0.998	0.40
Error (Stimulus*Sagittal* Coronal)	88	15.811		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	1793.609	2.335	0.16
Error	11	768.085		

Face Task: LPC Amplitude Correct Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Stimulus*Group	2	13.622	0.228	0.77
Error (Stimulus)	26	59.645		
Sagittal*Group	2	41.730	0.266	0.64
Error (Sagittal)	26	156.705		
Coronal*Group	4	27.397	0.913	0.42
Error (Coronal)	52	29.996		
Stimulus*Sagittal*Group	4	25.897	1.602	0.21
Error (Stimulus*Sagittal)	52	16.168		
Stimulus*Coronal*Group	8	9.583	0.581	0.64
Error (Stimulus*Coronal)	104	16.491		
Sagittal*Coronal*Group	8	9.075	0.514	0.72
Error (Sagittal*Coronal)	104	17.671		
Stimulus*Sagittal*Coronal* Group	16	7.066	1.462	0.21
Error (Stimulus*Sagittal* Coronal	208	4.833		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	29.800	0.064	0.80
Error	13	465.424		

Face Task: LPC Amplitude Incorrect Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Stimulus*Group	1	900.919	1.075	0.322
Error (Stimulus)	11	838.309		
Sagittal*Group	2	42.534	0.279	0.63
Error (Sagittal)	22	152.481		
Coronal*Group	4	13.374	0.443	0.73
Error (Coronal)	44	30.978		
Stimulus*Sagittal*Group	2	49.662	0.566	0.51
Error (Stimulus*Sagittal)	22	87.765		
Stimulus*Coronal*Group	4	15.039	0.591	0.57
Error (Stimulus*Coronal)	44	25.455		
Sagittal*Coronal*Group	8	24.713	0.858	0.45
Error (Sagittal*Coronal)	88	28.797		
Stimulus*Sagittal*Coronal*Group	8	9.188	0.296	0.82
Error (Stimulus*Sagittal*Coronal)	88	31.081		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	455.891	0.377	0.55
Error	11	1210.259		

Appendix E

Stimuli information:

Lang, Bradley, & Cuthbert (1999) ***International Affective Picture System (IAPS);***

Ekman & Friesen (1976) ***Pictures of Facial Affect.***

Table 3a.. Mean Arousal (A) and Valance (V) Ratings for the Repeated Neutral International Affective Picture System (IAPS) Slides.

Slide No.	Description	A	V	Slide No.	Description	A	V
1945	Turtle	4.51	4.22	5395	Boat	4.24	5.33
2215	Neutral Man	3.44	4.53	5500	Mushroom	3.18	5.34
2230	Neutral Face	4.14	4.41	5510	Mushroom	2.87	5.10
2516	Woman	3.45	4.76	5535	Still Life	4.28	4.72
2518	Quilting	3.37	5.85	5731	Flowers	3.04	5.58
2520	Elderly Man	4.23	4.14	5740	Plant	2.79	5.33
2575	Propeller	4.24	5.32	5900	Desert	4.11	5.75
2580	Chess	2.84	5.00	5920	Volcano	4.22	4.63
2600	Beer	3.98	5.77	5950	Lightening	4.73	5.34
2616	Dancer	4.88	5.85	6150	Outlet	2.89	5.00
2661	Baby	4.27	4.46	7000	Rolling Pin	2.15	5.06
2681	Police	4.87	4.26	7002	Towel	3.28	5.03
2720	Urinating	3.73	5.24	7004	Spoon	1.94	5.14
2749	Smoking	3.81	4.97	7006	Bowl	2.58	5.09
2810	Boy	4.56	4.14	7009	Mug	3.26	4.89
2830	Woman	3.43	4.48	7010	Basket	1.97	4.92
2840	Chess	2.55	4.90	7020	Fan	2.19	4.94
2850	Tourist	3.38	5.69	7025	Stool	2.98	4.79
2870	Teenager	3.11	5.41	7031	Shoes	2.36	4.80
2880	Shadow	3.17	5.22	7034	Hammer	2.96	4.91
2890	Twins	2.90	5.02	7035	Mug	2.75	5.15
3210	Surgery	4.50	4.21	7090	Book	2.92	5.44
4000	Artist	3.67	4.28	7096	Car	3.94	5.44
5120	Pine Needles	3.24	4.15	7100	Fire Hydrant	2.73	5.20
5130	Rocks	2.67	4.52	7130	Truck	3.20	4.75
7205	Scarves	2.98	5.75	7217	Clothes Rack	2.55	5.00

Table 3b. Mean Arousal (A) and Valence (V) Ratings for the Non-Repeated Neutral International Affective Picture System (IAPS) Slides

Slide No.	Description	A	V	Slide No.	Description	A	V
7235	Chair	2.94	5.06	2020	Adult	3.41	5.97
2190	Man	2.50	4.90	2200	Neutral Face	4.03	4.95
2271	Woman	3.85	4.11	2206	Finger Print	3.84	4.20
2351	Nursing Baby	4.87	5.49	2210	Neutral Face	3.44	4.36
2372	Woman	4.49	5.55	5455	Cockpit	4.71	5.72
2381	Girl	2.50	5.03	7150	Umbrella	2.56	4.69
2383	Secretary	3.36	4.79	7160	Fabric	3.08	5.05
2385	Girl	3.58	5.15	7170	Light Bulb	3.27	5.33
2410	Boy	4.40	4.54	7175	Lamp	1.87	4.95
2440	Neutral Girl	2.82	4.54	7182	Checkerboard	4.02	5.03
2480	Elderly Man	2.55	4.77	7190	Clock	3.80	5.59
2485	Man	3.72	5.91	7195	Teeth	4.40	5.88
2487	Musician	4.27	5.28	7233	Plate	2.96	5.15
2495	Man	3.47	5.14	7040	Dustpan	2.90	4.66
2514	Woman	3.53	5.21	7050	Hair Dryer	2.90	5.04
1313	Frog	4.71	5.76	7060	Trash Can	2.42	4.29
1560	Hawk	4.33	5.41	7080	Fork	2.67	5.10
1616	Bird	4.15	5.14	1670	Cow	3.16	5.88

Table 3c. Mean Arousal (A) and Valence (V) Ratings for the Unpleasant International Affective Picture System (IAPS) Slides

Slide No.	Description	A	V	Slide No.	Description	A	V
2205	Hospital	6.65	1.65	9050	Plane Crash	6.63	1.90
2730	Native Boy	6.93	1.80	9140	Cow	6.79	1.88
2800	Sad Child	6.87	1.41	9181	Dead Cows	6.09	1.98
3000	Mutilation	7.63	1.17	9220	Cemetery	6.16	1.86
3064	Mutilation	7.30	1.15	9252	Dead Body	6.93	1.53
3102	Burn Victim	7.15	1.22	9300	Dirty	6.21	1.83
3120	Dead Body	7.49	1.33	9405	Sliced Hand	6.77	1.59
3170	Baby Tumour	7.55	1.20	9432	Mastectomy	6.58	1.95
3180	Female	6.19	1.67	9433	Dead Man	6.71	1.35
3350	Infant	6.78	1.76	9570	Dog	6.45	1.47
6212	Soldier	6.53	1.81	9571	Cat	6.46	1.38
6243	Aimed Gun	6.34	1.90	9600	Ship	6.70	1.90
6350	Attack	7.52	1.44	9800	Skinhead	6.14	1.64
6821	Gang	6.62	1.85	9910	Car Accident	6.38	1.80
9040	Starving Child	6.44	1.50	9921	Fire	6.87	1.58

Table 3d. Mean Arousal (A) and Valence (V) Ratings for the Pleasant International Affective Picture System (IAPS) Slides.

Slide No.	Description	A	V	Slide No.	Description	A	V
1340	Women	5.25	7.63	2216	Children	6.29	7.85
1440	Seal	5.47	8.43	2304	Girls	3.91	7.70
1463	Kittens	5.81	7.81	2311	Mother	4.03	7.82
1500	Dog	5.15	7.72	2340	Family	4.53	8.34
1610	Rabbit	3.33	8.00	2341	Children	4.50	7.82
1710	Puppies	5.31	8.59	2360	Family	3.67	8.20
1750	Bunnies	4.02	8.59	2540	Mother	3.76	7.95
1920	Porpoise	4.31	7.94	2550	Couple	5.16	8.14
2040	Baby	4.97	8.74	2650	Boy	4.31	7.71
2050	Baby	5.10	8.62	5831	Seagulls	4.79	8.05
2080	Babies	4.94	8.46	7200	Brownie	4.85	7.77
2091	Girls	4.77	8.26	7330	Ice cream	5.54	7.96
2150	Baby	5.29	8.31	8185	Sky Divers	7.42	7.75
2165	Father	5.05	8.29	8190	Skier	6.16	8.08
2209	Bride	5.91	7.95	8220	Runners	5.41	7.53

Table 4. Pictures of Facial Affect (PFA) Slides and Number of Times Repeated.

Slide No.	Type	Repeated	Slide No.	Type	Repeated
3005	Neutral	10 times	3013	Pleasant	3 times
3023	Neutral	10 times	4010	Pleasant	2 times
1028	Neutral	10 times	1001	Pleasant	2 times
4020	Neutral	10 times	1014	Pleasant	2 times
2017	Neutral	10 times	2018	Pleasant	2 times
1013	Neutral	10 times	2012	Pleasant	2 times
2026	Neutral	10 times	3006	Pleasant	2 times
1021	Neutral	10 times	1015	Unpleasant	3 times
2003	Neutral	10 times	1002	Unpleasant	3 times
3012	Neutral	10 times	4004	Unpleasant	3 times
2011	Neutral	10 times	2028	Unpleasant	3 times
4002	Neutral	10 times	3015	Unpleasant	3 times
1006	Neutral	10 times	2013	Unpleasant	3 times
4009	Neutral	10 times	1008	Unpleasant	2 times
3024	Pleasant	3 times	1023	Unpleasant	2 times
2004	Pleasant	3 times	1030	Unpleasant	2 times
1029	Pleasant	3 times	3026	Unpleasant	2 times
2027	Pleasant	3 times	2006	Unpleasant	2 times
4003	Pleasant	3 times	3007	Unpleasant	2 times

Appendix F

Information and Consent Forms.

ERP Responses to Emotional Material as a Function of Personality Traits

Kristy Hill (Investigator, Masters of Psychology (Clinical) student)
and
Dr Frances Martin (Chief Investigator, Senior Lecturer, School of Psychology)

Date:

The purpose of this research is to investigate the role of personality traits in reactions and sensitivity to emotional information and to determine whether these differences in emotional sensitivity are reflected in differences in brain activity while processing emotional information. This research is being conducted as part of the requirements for a Masters in Psychology (Clinical) degree and will be carried out in the Cognitive Psychophysiology Laboratory at the School of Psychology, University of Tasmania (Hobart campus). Kristy Hill can be contacted on 0417 566 513 or e-mail: hillk@postoffice.utas.edu.au.

I am looking for female volunteers between the ages of 18 and 35. If you are a heavy tobacco or cannabis smoker, have a history of, or are currently suffering from, a neurological condition, you should not volunteer for this study. I will ask you to complete a questionnaire about these conditions before the experiment begins.

If you choose to volunteer for this research, you will be asked to come to the ERP laboratory for a one and a half hour session in which you will be asked to respond to pictures with an emotional content. All pictures will be presented via a computer, and you will be asked to focus on the computer screen and decide what emotions each picture makes you feel. While you are making your decisions, your brain activity and the time it takes you to respond will all be measured.

All of the information collected in this research will be kept entirely confidential. Following completion of the research, the data may be published, however, it will be published in such a way that no individual participant will be identifiable.

There are no known risks associated with having the electrical activity of your brain recorded, however, if you have sensitive skin, you should let me know. Participation in this research is entirely voluntary. You may choose to withdraw from the study at any time without prejudice. Deciding to withdraw from this research at any time will NOT affect your academic standing in any way. Participants will be given copies of this information sheet and the statement of informed consent to keep.

If you have any questions, or would like any additional information regarding this research please contact Kristy Hill on 0417 566 513 or by e-mail at hillk@postoffice.utas.edu.au, or Dr Frances Martin on (03) 62 262262.

This research has received ethical approval from the Northern Social Sciences Human Research Ethics Committee. If you have any questions regarding the ethical nature or complaints about the manner in which the study is conducted, you may contact the Chair of the Northern Tasmanian Social Sciences Human Research Ethics Committee (Professor Roger Fay on 03 63 243576) or Executive Officer (Amanda McAully on 03 62 262763). If you have any ethical or personal concerns related to the viewing of emotional pictures or to any other aspect of the research, you may also choose to discuss these concerns with a University Student Counselor (located on the top floor of the TUU Building: Phone 62 262679).

Dr Frances Martin
(Chief Investigator)

Kristy Hill
(Student Investigator)

ERP Responses to Emotional Material as a Function of Personality Traits

Kristy Hill (Investigator, Masters of Psychology (Clinical) student)
and
Dr Frances Martin (Chief Investigator, Senior Lecturer, School of Psychology)

Participant Consent Statement:

I have read and understood the *Information Sheet* for this research. The nature and possible effects of the research have been explained to me. Any questions that I have asked have been answered to my satisfaction.

I understand that the research requires me to attend and respond to the emotional content of pictures while my brain activity is being recorded. Setting up the experiment and completing the task will take approximately one and a half hours. I understand that I will be asked about recreational drug habits, use of prescription medication, and any neurological conditions. I understand that I should indicate to the experimenter if I have sensitive skin.

I understand that all research data will be treated as confidential. I agree that research data gathered for the study may be published provided that I cannot be identified as a participant.

I agree to participate in the investigation and understand that I may withdraw at any time without prejudice to my academic standing.

Name of participant..

Signature of participant.. Date............................

Investigator Consent Statement

I have explained this research and the implications of participation in it to this volunteer and I believe that the consent is informed and that he/she understands the implications of participation.

Name of investigator..

Signature of investigator... Date............................

Appendix G

Repeated Measures ANOVAs for Reaction Time and Accuracy.

Reaction Time Correct Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Task	1	0.276	24.617	0.000
Task*Group	1	0.030	2.673	0.113
Error (Task)	28	0.011		
Stimulus	2	0.021	3.655	0.040
Stimulus*Group	2	0.002	0.282	0.719
Error (Stimulus)	56	0.006		
Task*Stimulus	2	0.040	11.646	0.000
Task*Stimulus*Group	2	0.001	0.273	0.749
Error (Task*Stimulus)	56	0.003		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	0.045	0.012	0.743
Error		0.092		

Accuracy: Correct Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Task	1	358.557	0.999	0.326
Task*Group	1	193.087	0.538	0.469
Error (Task)	28	358.954		
Stimulus	2	15807.958	17.229	0.000
Stimulus*Group	2	1922.624	2.095	0.152
Error (Stimulus)	56	917.535		
Task*Stimulus	2	27.921	0.163	0.848
Task*Stimulus*Group	2	27.313	0.159	0.851
Error (Task*Stimulus)	56	171.376		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	1758.557	2.956	0.097
Error	28	594.950		

Accuracy: Incorrect Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Task	1	89.392	2.211	0.148
Task*Group	1	5.208	0.129	0.722
Error (Task)	28	40.431		
Stimulus	1	380.106	2.011	0.167
Stimulus*Group	1	64.324	0.340	0.564
Error (Stimulus)	28	188.979		
Task*Stimulus	1	2077.385	35.559	0.000
Task*Stimulus*Group	1	219.086	3.750	0.063
Error (Task*Stimulus)	28	58.421		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	1736.059	7.342	0.011
Error	28	236.472		

Appendix H

Repeated Measures ANOVAs for Event-Related Potential Data.

P300 Amplitude: Correct Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Task	1	2231.998	17.020	0.000
Task*Group	1	112.742	0.860	0.362
Error (Task)	28	131.136		
Stimulus	2	634.023	12.890	0.000
Stimulus*Group	2	40.049	0.814	0.437
Error (Stimulus)	56	49.188		
Sagittal	2	10822.064	42.896	0.000
Sagittal*Group	2	240.034	0.951	0.350
Error (Sagittal)	56	252.287		
Coronal	4	3900.707	57.950	0.000
Coronal*Group	4	28.472	0.423	0.695
Error (Coronal)	112	67.312		
Task*Stimulus	2	154.076	4.058	0.025
Task*Stimulus*Group	2	13.317	0.351	0.691
Error (Task*Stimulus)	56	37.965		
Task*Sagittal	2	1492.158	40.238	0.000
Task*Sagittal*Group	2	26.873	0.725	0.438
Error (Task*Sagittal)	56	37.084		
Stimulus*Sagittal	4	75.380	3.568	0.028
Stimulus*Sagittal*Group	2	26.873	0.725	0.312
Error (Stimulus*Sagittal)	112	21.127		
Task*Stimulus*Sagittal	4	92.016	4.537	0.010
Task*Stimulus*Sagittal*Group	4	6.732	0.332	0.757
Error (Task*Stimulus*Sagittal)	112	20.281		
Task*Coronal	4	88.654	8.861	0.000
Task*Coronal*Group	4	13.701	1.370	0.260
Error (Task*Coronal)	112	10.004		
Stimulus*Coronal	8	38.729	4.320	0.002
Stimulus*Coronal*Group	8	1.783	0.199	0.949
Error (Stimulus*Coronal)	224	8.965		
Task*Stimulus*Coronal	8	10.713	1.165	0.330
Task*Stimulus*Coronal*Group	8	6.642	0.722	0.587
Error (Task*Stimulus*Coronal)	224	9.196		
Sagittal*Coronal	8	152.222	5.450	0.000
Sagittal*Coronal*Group	8	6.204	0.222	0.941
Error (Sagittal*Coronal)	224	27.930		
Task*Sagittal*Coronal	8	37.714	3.443	0.014
Task*Sagittal*Coronal*Group	8	7.505	0.685	0.587
Error (Task*Sagittal*Coronal)	224	10.953		
Stimulus*Sagittal*Coronal	16	11.707	1.078	0.374
Stimulus*Sagittal*Coronal*Group	16	5.247	0.483	0.758
Error (Stimulus*Sagittal*Coronal)	448	10.863		
Task*Stimulus*Sagittal*Coronal	16	8.024	0.447	0.726
Task*Stimulus*Sagittal*Coronal*Group	16	14.487	0.807	0.497
Error (Task*Stimulus*Sagittal*Coronal	448	17.960		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	548.084	0.938	0.341
Error	28	584.330		

P300 Latency: Correct Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Task	1	27801.813	1.172	0.288
Task*Group	1	28330.561	1.195	0.284
Error (Task)	28	23715.563		
Stimulus	2	28425.334	4.374	0.018
Stimulus*Group	2	21867.948	3.365	0.043
Error (Stimulus)	56	6498.073		
Sagittal	2	685819.915	15.245	0.000
Sagittal*Group	2	14610.902	0.325	0.624
Error (Sagittal)	56	44987.557		
Coronal	4	12451.210	0.865	0.436
Coronal*Group	4	16741.852	1.155	0.325
Error (Coronal)	112	14494.221		
Task*Stimulus	2	10719.961	1.918	0.157
Task*Stimulus*Group	2	1064.340	0.190	0.825
Error (Task*Stimulus)	56	5589.690		
Task*Sagittal	2	11259.609	2.103	0.138
Task*Sagittal*Group	2	15018.667	2.805	0.076
Error (Task*Sagittal)	56	5354.690		
Stimulus*Sagittal	4	9155.815	2.831	0.033
Stimulus*Sagittal*Group	4	3135.954	0.970	0.421
Error (Stimulus*Sagittal)	112	3233.606		
Task*Stimulus*Sagittal	4	5838.357	1.618	0.191
Task*Stimulus*Sagittal*Group	4	4857.841	1.346	0.265
Error (Task*Stimulus*Sagittal)	112	3608.663		
Task*Coronal	4	3911.322	1.416	0.244
Task*Coronal*Group	4	1547.560	0.560	0.639
Error (Task*Coronal)	112	2761.287		
Stimulus*Coronal	8	6797.153	1.854	0.112
Stimulus*Coronal*Group	8	8822.620	2.406	0.044
Error (Stimulus*Coronal)	224	3666.467		
Task*Stimulus*Coronal	8	3379.768	1.184	0.321
Task*Stimulus*Coronal*Group	8	2833.408	0.993	0.422
Error (Task*Stimulus*Coronal)	224	2853.635		
Sagittal*Coronal	8	10684.254	1.953	0.090
Sagittal*Coronal*Group	8	2833.603	0.518	0.761
Error (Sagittal*Coronal)	224	5470.725		
Task*Sagittal*Coronal	8	2385.157	0.853	0.524
Task*Sagittal*Coronal*Group	8	4821.493	1.724	0.125
Error (Task*Sagittal*Coronal)	224	2796.326		
Stimulus*Sagittal*Coronal	16	3560.305	1.329	0.224
Stimulus*Sagittal*Coronal*Group	16	2772.983	1.035	0.412
Error (Stimulus*Sagittal*Coronal)	448	2678.434		
Task*Stimulus*Sagittal*Coronal	16	2281.741	0.937	0.491
Task*Stimulus*Sagittal*Coronal*Group	16	3056.898	1.255	0.265
Error (Task*Stimulus*Sagittal*Coronal)	448	2435.746		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	470976.148	3.445	0.074
Error	28	136728.220		

LPC Amplitude Correct Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Task	1	17.515	0.175	0.679
Task*Group	1	93.971	0.941	0.340
Error (Task)	28	99.883		
Stimulus	2	3753.367	65.368	0.000
Stimulus*Group	2	7.238	0.126	0.872
Error (Stimulus)	56	57.419		
Sagittal	2	5279.275	21.317	0.000
Sagittal*Group	2	1431.000	5.778	0.015
Error (Sagittal)	56	247.655		
Coronal	4	1596.288	23.533	0.000
Coronal*Group	4	38.906	0.574	0.613
Error (Coronal)	112	67.832		
Task*Stimulus	2	26.392	0.673	0.513
Task*Stimulus*Group	2	86.919	2.215	0.119
Error (Task*Stimulus)	56	39.243		
Task*Sagittal	2	437.922	9.992	0.000
Task*Sagittal*Group	2	15.262	0.348	0.672
Error (Task*Sagittal)	56	43.826		
Stimulus*Sagittal	4	75.900	4.792	0.004
Stimulus*Sagittal*Group	4	20.466	1.291	0.283
Error (Stimulus*Sagittal)	112	15.838		
Task*Stimulus*Sagittal	4	137.552	7.832	0.000
Task*Stimulus*Sagittal*Group	4	7.255	0.413	0.701
Error (Task*Stimulus*Sagittal)	112	17.563		
Task*Coronal	4	217.817	5.945	0.003
Task*Coronal*Group	4	37.055	1.011	0.376
Error (Task*Coronal)	112	36.638		
Stimulus*Coronal	8	109.890	12.325	0.000
Stimulus*Coronal*Group	8	2.732	0.306	0.908
Error (Stimulus*Coronal)	224	8.916		
Task*Stimulus*Coronal	8	13.369	0.958	0.433
Task*Stimulus*Coronal*Group	8	34.265	2.457	0.050
Error (Task*Stimulus*Coronal)	224	13.948		
Sagittal*Coronal	8	377.527	5.585	0.001
Sagittal*Coronal*Group	8	97.700	1.445	0.234
Error (Sagittal*Coronal)	224	67.599		
Task*Sagittal*Coronal	8	34.382	0.811	0.473
Task*Sagittal*Coronal*Group	8	37.487	0.884	0.438
Error (Task*Sagittal*Coronal)	224	42.388		
Stimulus*Sagittal*Coronal	16	8.062	1.275	0.260
Stimulus*Sagittal*Coronal*Group	16	7.709	1.219	0.290
Error (Stimulus*Sagittal*Coronal)	448	6.321		
Task*Stimulus*Sagittal*Coronal	16	8.623	1.147	0.337
Task*Stimulus*Sagittal*Coronal*Group	16	3.375	0.449	0.847
Error (Task*Stimulus*Sagittal*Coronal)	448	2.852		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	1310.904	2.565	0.120
Error	28	511.126		

LPC Latency: Correct Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Task	1	444572.339	26.805	0.000
Task*Group	1	67900.593	4.094	0.053
Error (Task)	28	16585.245		
Stimulus	2	110384.219	12.314	0.000
Stimulus*Group	2	31907.427	3.560	0.038
Error (Stimulus)	56	8963.928		
Sagittal	2	4111664.530	128.907	0.000
Sagittal*Group	2	12473.249	0.391	0.599
Error (Sagittal)	56	31896.254		
Coronal	4	170633.214	9.772	0.000
Coronal*Group	4	23849.200	1.366	0.262
Error (Coronal)	112	17462.090		
Task*Stimulus	2	121849.108	10.106	0.000
Task*Stimulus*Group	2	40966.860	3.398	0.042
Error (Task*Stimulus)	56	12056.734		
Task*Sagittal	2	358674.008	51.539	0.000
Task*Sagittal*Group	2	10968.622	1.576	0.220
Error (Task*Sagittal)	56	6959.311		
Stimulus*Sagittal	4	64679.536	7.006	0.000
Stimulus*Sagittal*Group	4	2336.410	0.253	0.857
Error (Stimulus*Sagittal)	112	9232.401		
Task*Stimulus*Sagittal	4	22276.573	3.220	0.032
Task*Stimulus*Sagittal*Group	4	12819.095	1.853	0.151
Error (Task*Stimulus*Sagittal)	112	6917.264		
Task*Coronal	4	2596.772	0.289	0.776
Task*Coronal*Group	4	6133.301	0.681	0.527
Error (Task*Coronal)	112	9000.923		
Stimulus*Coronal	8	4979.414	1.468	0.193
Stimulus*Coronal*Group	8	1158.520	0.342	0.911
Error (Stimulus*Coronal)	224	3391.701		
Task*Stimulus*Coronal	8	8840.299	2.719	0.019
Task*Stimulus*Coronal*Group	8	48.134	0.015	1.000
Error (Task*Stimulus*Coronal)	224	3251.338		
Sagittal*Coronal	8	102417.976	9.986	0.000
Sagittal*Coronal*Group	8	3700.549	0.361	0.831
Error (Sagittal*Coronal)	224	10256.591		
Task*Sagittal*Coronal	8	13736.228	4.373	0.000
Task*Sagittal*Coronal*Group	8	5897.704	1.878	0.090
Error (Task*Sagittal*Coronal)	224	3140.891		
Stimulus*Sagittal*Coronal	16	4953.035	1.507	0.144
Stimulus*Sagittal*Coronal*Group	16	5701.844	1.735	0.080
Error (Stimulus*Sagittal*Coronal)	448	3286.282		
Task*Stimulus*Sagittal*Coronal	16	3708.370	1.184	0.303
Task*Stimulus*Sagittal*Coronal*Group	16	2978.757	0.951	0.485
Error (Task*Stimulus*Sagittal*Coronal)	448	3131.955		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	10490.253	0.083	0.775
Error	28	125923.314		

P300 Amplitude Incorrect Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Task	1	5393.512	17.547	0.000
Task*Group	1	726.3-00	2.363	0.139
Error (Task)	22	307.370		
Stimulus	1	855.971	2.664	0.117
Stimulus*Group	1	11.301	0.035	0.853
Error (Stimulus)	22	321.305		
Sagittal	2	5761.243	29.400	0.000
Sagittal*Group	2	26.616	0.136	0.771
Error (Sagittal)	44	195.962		
Coronal	4	2005.371	30.791	0.000
Coronal*Group	4	92.216	1.416	0.250
Error (Coronal)	88	65.128		
Task*Stimulus	1	1222.460	5.313	0.031
Task*Stimulus*Group	1	0.347	0.002	0.969
Error (Task*Stimulus)	22	230.102		
Task*Sagittal	2	1014.503	14.629	0.000
Task*Sagittal*Group	2	74.658	1.077	0.325
Error (Task*Sagittal)	44	69.347		
Stimulus*Sagittal	2	137.427	2.720	0.099
Stimulus*Sagittal*Group	2	11.859	0.235	0.706
Error (Stimulus*Sagittal)	44	50.518		
Task*Stimulus*Sagittal	2	26.428	0.846	0.400
Task*Stimulus*Sagittal*Group	2	4.629	0.148	0.783
Error (Task*Stimulus*Sagittal)	44	31.253		
Task*Coronal	4	76.644	3.202	0.037
Task*Coronal*Group	4	49.467	2.067	0.125
Error (Task*Coronal)	88	23.936		
Stimulus*Coronal	4	55.450	2.825	0.054
Stimulus*Coronal*Group	4	29.562	1.506	0.226
Error (Stimulus*Coronal)	88	19.631		
Task*Stimulus*Coronal	4	19.611	0.976	0.396
Task*Stimulus*Coronal*Group	4	10.891	0.542	0.617
Error (Task*Stimulus*Coronal)	88	20.086		
Sagittal*Coronal	8	134.328	2.704	0.051
Sagittal*Coronal*Group	8	36.249	0.730	0.540
Error (Sagittal*Coronal)	176	49.669		
Task*Sagittal*Coronal	8	31.100	2.257	0.072
Task*Sagittal*Coronal*Group	8	9.031	0.655	0.619
Error (Task*Sagittal*Coronal)	176	13.782		
Stimulus*Sagittal*Coronal	8	7.540	0.402	0.758
Stimulus*Sagittal*Coronal*Group	8	27.149	1.448	0.236
Error (Stimulus*Sagittal*Coronal)	\176	18.743		
Task*Stimulus*Sagittal*Coronal	8	9.551	0.842	0.497
Task*Stimulus*Sagittal*Coronal*Group	8	15.492	1.366	0.254
Error (Task*Stimulus*Sagittal*Coronal)	176	11.340		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	1969.432	3.275	0.084
Error	22	601.375		

P300 Latency: Incorrect Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Task	1	802.626	0.038	0.846
Task*Group	1	0.793	0.000	0.995
Error (Task)	22	20874.816		
Stimulus	1	318.304	0.054	0.819
Stimulus*Group	1	262.204	0.044	0.835
Error (Stimulus)	22	5909.983		
Sagittal	2	392761.882	21.661	0.000
Sagittal*Group	2	3642.638	0.201	0.746
Error (Sagittal)	44	18132.063		
Coronal	4	1643.897	0.230	0.921
Coronal*Group	4	5360.250	0.749	0.507
Error (Coronal)	88	7157.286		
Task*Stimulus	1	7.323	0.001	0.979
Task*Stimulus*Group	1	1651.290	0.155	0.698
Error (Task*Stimulus)	22	10664.483		
Task*Sagittal	2	18344.760	4.007	0.027
Task*Sagittal*Group	2	68.969	0.015	0.983
Error (Task*Sagittal)	44	4578.129		
Stimulus*Sagittal	2	300.922	0.072	0.884
Stimulus*Sagittal*Group	2	3277.139	0.787	0.432
Error (Stimulus*Sagittal)	44	4163.088		
Task*Stimulus*Sagittal	2	1270.387	0.318	0.680
Task*Stimulus*Sagittal*Group	2	1014.042	0.254	0.727
Error (Task*Stimulus*Sagittal)	44	3997.004		
Task*Coronal	4	3640.592	0.578	0.601
Task*Coronal*Group	4	10121.506	1.607	0.205
Error (Task*Coronal)	88	6297.908		
Stimulus*Coronal	4	3449.664	1.363	0.262
Stimulus*Coronal*Group	4	1814.285	0.717	0.543
Error (Stimulus*Coronal)	88	2530.690		
Task*Stimulus*Coronal	4	3052.545	1.274	0.290
Task*Stimulus*Coronal*Group	4	4079.430	1.702	0.170
Error (Task*Stimulus*Coronal)	88	2396.614		
Sagittal*Coronal	8	3239.581	0.722	0.586
Sagittal*Coronal*Group	8	3922.285	0.874	0.487
Error (Sagittal*Coronal)	176	4488.756		
Task*Sagittal*Coronal	8	5075.175	2.025	0.081
Task*Sagittal*Coronal*Group	8	2572.679	1.026	0.406
Error (Task*Sagittal*Coronal)	176	2506.494		
Stimulus*Sagittal*Coronal	8	1171.356	0.615	0.697
Stimulus*Sagittal*Coronal*Group	8	2172.698	1.141	0.343
Error (Stimulus*Sagittal*Coronal)	176	1904.894		
Task*Stimulus*Sagittal*Coronal	8	2125.115	1.005	0.421
Task*Stimulus*Sagittal*Coronal*Group	8	1382.605	0.654	0.671
Error (Task*Stimulus*Sagittal*Coronal)	176	2114.138		

Test of Between-Subject Effects

Source	df	Mean Square	F	Sig
Group	1	368237.837	4.676	0.042
Error	22	78744.840		

LPC Amplitude: Incorrect Responses
Test of Within-Subjects Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Task	1	1316.982	2.991	0.098
Task*Group	1	585.758	1.330	0.261
Error (Task)	22	440.265		
Stimulus	1	1984.081	2.791	0.109
Stimulus*Group	1	5.392	0.008	0.931
Error (Stimulus)	22	710.953		
Sagittal	2	2931.792	15.245	0.000
Sagittal*Group	2	92.104	0.479	0.561
Error (Sagittal)	44	192.315		
Coronal	4	1118.253	14.979	0.000
Coronal*Group	4	144.565	1.936	0.147
Error (Coronal)	88	74.655		
Task*Stimulus	1	2545.205	4.373	0.048
Task*Stimulus*Group	1	169.926	0.292	0.594
Error (Task*Stimulus)	22	581.975		
Task*Sagittal	2	65.159	1.000	0.348
Task*Sagittal*Group	2	11.094	0.170	0.750
Error (Task*Sagittal)	44	65.149		
Stimulus*Sagittal	2	231.793	3.931	0.038
Stimulus*Sagittal*Group	2	4.512	0.077	0.884
Error (Stimulus*Sagittal)	44	58.966		
Task*Stimulus*Sagittal	2	33.043	0.953	0.378
Task*Stimulus*Sagittal*Group	2	10.654	0.307	0.690
Error (Task*Stimulus*Sagittal)	44	34.678		
Task*Coronal	4	85.992	2.017	0.066
Task*Coronal*Group	4	41.384	1.259	0.296
Error (Task*Coronal)	88	32.862		
Stimulus*Coronal	4	74.913	2.171	0.116
Stimulus*Coronal*Group	4	34.345	0.995	0.388
Error (Stimulus*Coronal)	88	34.505		
Task*Stimulus*Coronal	4	46.240	1.593	0.208
Task*Stimulus*Coronal*Group	4	27.916	0.962	0.403
Error (Task*Stimulus*Coronal)	88	29.020		
Sagittal*Coronal	8	147.196	3.810	0.008
Sagittal*Coronal*Group	8	32.913	0.852	0.490
Error (Sagittal*Coronal)	176	38.634		
Task*Sagittal*Coronal	8	4.820	0.177	0.942
Task*Sagittal*Coronal*Group	8	24.037	0.882	0.473
Error (Task*Sagittal*Coronal)	176	27.267		
Stimulus*Sagittal*Coronal	8	9.460	0.656	0.643
Stimulus*Sagittal*Coronal*Group	8	7.100	0.493	0.764
Error (Stimulus*Sagittal*Coronal)	176	14.416		
Task*Stimulus*Sagittal*Coronal	8	15.104	0.566	0.634
Task*Stimulus*Sagittal*Coronal*Group	8	5.252	0.197	0.893
Error (Task*Stimulus*Sagittal*Coronal)	176	26.694		

Test of Between-Subjects Effects

Source	df	Mean Square	F	Sig
Group	1	6810.128	8.054	0.010
Error	22	845.536		

LPC Latency: Incorrect Responses
Test of Within-Subject Effects
Greenhouse-Geisser

Source	df	Mean Square	F	Sig
Task	1	199319.754	12.123	0.002
Task*Group	1	1778.109	0.108	0.745
Error (Task)	22	16441.093		
Stimulus	1	63772.407	5.783	0.025
Stimulus*Group	1	39585.185	3.571	0.072
Error (Stimulus)	22	11085.508		
Sagittal	2	2469035.138	85.213	0.000
Sagittal*Group	2	11695.043	0.404	0.591
Error (Sagittal)	44	28974.734		
Coronal	4	55338.232	4.721	0.007
Coronal*Group	4	7254.190	0.619	0.585
Error (Coronal)	88	11722.617		
Task*Stimulus	1	2261.331	0.154	0.699
Task*Stimulus*Group	1	36930.420	2.513	0.127
Error (Task*Stimulus)	22	14697.533		
Task*Sagittal	2	60950.823	7.175	0.004
Task*Sagittal*Group	2	6889.766	0.811	0.429
Error (Task*Sagittal)	44	8494.405		
Stimulus*Sagittal	2	2047.419	0.236	0.756
Stimulus*Sagittal*Group	2	4232.569	0.488	0.588
Error (Stimulus*Sagittal)	44	8668.511		
Task*Stimulus*Sagittal	2	3291.152	0.439	0.617
Task*Stimulus*Sagittal*Group	2	5399.385	0.720	0.473
Error (Task*Stimulus*Sagittal)	44	7500.809		
Task*Coronal	4	11943.102	3.062	0.028
Task*Coronal*Group	4	2307.405	0.592	0.641
Error (Task*Coronal)	88	3900.411		
Stimulus*Coronal	4	4544.858	0.700	0.537
Stimulus*Coronal*Group	4	9217.826	1.419	0.249
Error (Stimulus*Coronal)	88	6495.745		
Task*Stimulus*Coronal	4	485.462	0.148	0.933
Task*Stimulus*Coronal*Group	4	4241.691	1.290	0.285
Error (Task*Stimulus*Coronal)	88	3287.900		
Sagittal*Coronal	8	50890.127	6.804	0.000
Sagittal*Coronal*Group	8	7859.938	1.051	0.390
Error (Sagittal*Coronal)	176	7479.692		
Task*Sagittal*Coronal	8	16513.612	3.134	0.014
Task*Sagittal*Coronal*Group	8	2339.490	0.444	0.798
Error (Task*Sagittal*Coronal)	176	5268.783		
Stimulus*Sagittal*Coronal	8	1247.504	0.288	0.916
Stimulus*Sagittal*Coronal*Group	8	963.842	0.223	0.950
Error (Stimulus*Sagittal*Coronal)	176	4326.875		
Task*Stimulus*Sagittal*Coronal	8	3927.231	0.992	0.422
Task*Stimulus*Sagittal*Coronal*Group	8	5336.661	1.348	0.254
Error (Task*Stimulus*Sagittal*Coronal)	176	3959.159		

Test of Between-Subject Effects

Source	df	Mean Square	F	Sig
Group	1	35471.378	0.349	0.016
Error	22	101687.422		